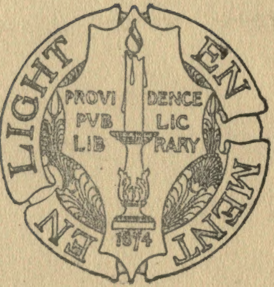

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FARMERS' BULLETINS
Nos. 1401-1425

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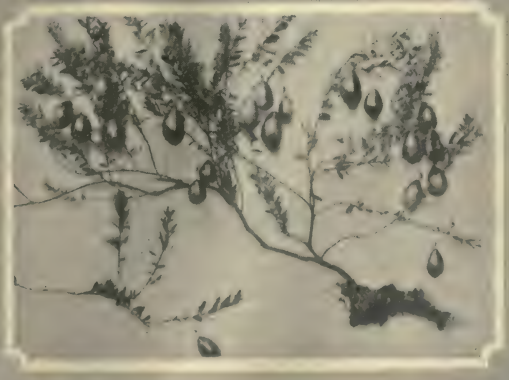
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1401

MANAGING CRANBERRY FIELDS



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FARMERS' BULLETIN 1400, Establishing Cranberry Fields, discusses many principles involved in cranberry growing and gives directions for establishing cranberry fields.

This bulletin discusses the management of established cranberry fields. This involves winter, summer, and fall flooding for winter protection, the control of insects and diseases, and the protection of the crop from frost injury. Methods of controlling weeds are discussed and many weeds illustrated.

The third bulletin of this series is Farmers' Bulletin 1402, Cranberry Harvesting and Handling.

Other bulletins which should be read in conjunction with this series are Farmers' Bulletin 860, Cranberry Insect Problems and Suggestions for Solving Them, and Farmers' Bulletin 1081, Cranberry Diseases and Their Control.

Washington, D. C. Issued May, 1924

MANAGING CRANBERRY FIELDS.[1]

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MANAGING cranberry fields necessitates a knowledge of insect and disease control, flooding for protection against winter injury and frosts, weather forecasting, fertilizers, and weeding. Much of this knowledge can be gained only by experience, for the conditions surrounding cranberry fields are extremely variable. Details regarding each operation will therefore be varied to suit local needs.

CONTROL OF INSECTS AND DISEASES.

The cranberry is subject to several serious insect pests. These pests are most harmful on fields without proper water supplies for flooding and affect the foliage, fruit, vines, and root. Farmers' Bulletin No. 860, Cranberry Insect Problems and Suggestions for Solving Them, gives brief descriptions of these pests, their life histories, and the means found most effective in controlling them. The bulletin mentioned states:

> An abundant water supply, permitting flooding and reflooding at the proper times, is the best remedy for insect injury in cranberry bogs, and when the sites of new bogs are to be chosen this should always be borne in mind. On cranberry land where the water supply is insufficient, however, spraying, sanding, and other measures will have to be used.

Farmers' Bulletin No. 1081, Cranberry Diseases and Their Control, gives information on the diseases of the cranberry. The bulletin states that there are numerous diseases which affect the cranberry and that they are gradually spreading and becoming more serious. Every field differs from every other one, and conditions vary even in different parts of the same field. Experience, careful observation, and study must determine the most satisfactory methods of handling a particular field in order to obtain the most vigorous and productive vines.

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[1] In Massachusetts and New Jersey the name "bog" is commonly applied to areas planted to cranberries, though very small areas are referred to as "yards." In Wisconsin the word "marsh" is used in place of "bog." The words "bog" and "marsh" both refer to swampy ground. The popular conception of a bog or marsh is a swamp where mosquitoes breed, a nuisance in any neighborhood. Neither term, then, is fitly applied to a developed well-drained cranberry property. To apply a term in keeping with modern methods of raising cranberries, the term "field" is used in this bulletin, and a properly drained area planted to cranberries is called a "cranberry field."

There is evidence that spraying with Bordeaux mixture results in an accumulative injury on sanded areas in Massachusetts. This fungicide is not recommended for indiscriminate use on fields in that State.

RESANDING.

The use of sand on cranberry fields was discussed in Farmers' Bulletin No. 1400, Establishing Cranberry Fields. From 2 to 3 inches of sand to be applied before planting was recommended for certain regions and also resanding with one-fourth to one-third of an inch of sand every year until the field came into full bearing to thoroughly root all runners.

After the field has come into full bearing it should be resanded every second or third year with one-third to one-half inch of sand. This resanding encourages the runners to root, covers débris, helps in the control of certain insects, and aids in preventing frosts.

WINTER FLOODING.

Without protection the cranberry vine will not always endure the winters in the regions where it is grown, except on the Pacific coast. In the wild it grows mainly along streams and in swamps where the water rises in winter and covers and protects it. Growers have found it necessary to give similar protection to the plants during the winter. Wherever possible, cranberry fields receive winter protection by the use of water, called "winter flooding." In Massachusetts and New Jersey some fields can not be flooded during the winter. They are considered much less valuable than those which can be flooded, as they are liable to such severe injury in winter that all prospects for a crop may be destroyed.

Winter flooding can not be applied by the calendar. It should be done in the fall or early winter, but as late as possible without serious risk of injury from winterkilling. It should not be delayed after the soil in the field to be flooded has frozen 2 or 3 inches deep. This seldom occurs in New Jersey and Massachuetts before December, and sometimes not before January. In Wisconsin flooding is sometimes necessary in late October on new plantings, but not generally until November or early December on old fields.

On some fields the winter water is kept just deep enough to cover the vines, which freeze into the ice. On others it is kept at a depth of several feet. In general, a depth of from 1 to 2 feet is probably best.

During the winter the dikes and flumes should be inspected from time to time, especially during thaws. Some fields, notably those flooded by pumping, must be given additional water several times to maintain the desired level, for if the water is raised or lowered when ice covers the field the ice may break and shift, tearing up the vines.

The water ordinarily should be drained off by April 1 in New Jersey and Massachusetts, but if necessary it may be left on until the middle of May. In Wisconsin the water is removed in April or early May, but the fields are reflooded if injurious temperatures threaten later.

Winter flooding is not generally practiced on the Pacific coast.

SUMMER AND FALL FLOODING.

Cranberry fields are reflooded from time to time after the winter flood is drained off and before the vines blossom. Reflooding has been found the most effective and most economical means of protection against frost injury and of controlling some insects. It is also done occasionally by some growers to control weeds and diseases, and water is sometimes needed in dry weather for irrigation.

Injudicious flooding, however, may injure the vines and destroy the crop. The cranberry vine, like all plants, uses oxygen in respiration. Water contains varying amounts of oxygen which the cranberry can use. Dark-colored water from swamps and water from reservoirs and ponds with mud bottoms contains less oxygen than that from clear streams and from ponds with sandy or gravelly bottoms.

In winter and in cool weather the respiration of plants is slow and little oxygen is used by the cranberry. In warm weather, when the vines are growing rapidly, respiration is much more rapid. The water used for flooding may then contain too little oxygen for the plants, and they may smother if submerged too long. On bright, sunny days cranberry vines give off more oxygen than they use, and there is less danger in flooding them than when the days are cloudy. On warm cloudy days the vines give off little or no oxygen, but by respiration use up that contained in the water, and their more tender parts, including the blossom buds, are very likely to smother unless the flooding period is brief.

Vines in bloom must never be flooded, and reflowing should not be done after the berries have set and begun to grow, unless the fruit worm or girdler is doing great harm. Flooding the young berries sets up an infection of putrefactive fungi which impairs their keeping quality.

In Masschusetts, if the fruit worm or the girdler has been active, the crop should be gathered by September 25 and the field promptly flooded for a period of two weeks. The vines are maturing by this time and will endure this prolonged submergence without danger. In New Jersey there are fewer fruit worms than in Massachusetts, and one week of flooding is enough. Fall flooding is advisable as a regular preventive against these pests.

FLOODING AND FROST PROTECTION.

"Damaging frosts invariably occur in Wisconsin in the month [of May], often in June, rarely in July, occasionally in August, and invariably again in the month of September; while midsummer frosts are unknown in the East and seldom occur in the month of June."[2] Although damaging frosts are more frequent in Wisconsin than in New Jersey and Massachusetts, yet some frost protection is needed nearly every year in both the latter States.

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[2] Cox, Henry J. Frost and temperature conditions in the cranberry marshes of Wisconsin. U. S. Dept. Agr., Weather Bur. Bul. T, 121 p., 31 fig. 1910.

Cranberry fields after growth starts withstand without injury temperatures as low as 29° F. In the spring the winter buds of the cranberry will endure a temperature of 25° F., even after they have begun to swell. Later, when the tender new growth has started, frosts with minimum temperatures below 29° F. are always dangerous. When the berries turn greenish white just before ripening, a temperature of 27° F. will cause no injury, but one of 24° F. will harm them if long continued.

When ripe, Early Black and Howes cranberries begin to freeze at or slightly above 22° F., but no softening of the fruit occurs following exposure to a temperature of 23° F. Ripe Howes berries are so resistant to frost that under field conditions often only 10 per cent of the fruit freezes at a temperature of 16° F. and only 20 per cent at 14° F. Sometimes, however, 25 per cent is softened if exposed to a temperature of 18° F. The Early Black variety is less resistant to these low temperatures than the Howes.

The value of sand as a means of frost protection was discussed in Farmers' Bulletin No. 1400, Establishing Cranberry Felds, in connection with sanding. Briefly, the sand covering of a field radiates its heat at night, thus giving considerable protection against frost. In Wisconsin the minimum temperature on cold summer nights among vines on sanded areas will average 6 degrees higher than among vines on peat. Frosts often form on peat fields when none occurs on near-by sanded areas. For example, for eight seasons at the Wisconsin Cranberry Experiment Station no frost protection was found necessary on sanded areas between May 10 and September 20, while severe frosts occurred on unsanded fields during this period.

When the growth of vines is rank the soil is screened from the sun and is warmed less during the day than when the growth is less dense. Such areas are more liable to frosts than are those less densely covered. Moreover, leaves, weeds, grasses, moss, and decaying vegetation are very poor conductors of heat. The soil of fields that are not kept resanded is covered with decaying leaves and other material, and such fields are more often frosted than well-sanded ones.

Air drainage is often very important in frost protection. Cold air is heavier than warm air, and if there is no wind it naturally settles into low areas, such as those occupied by cranberry fields. Because of this, frost may occur there when none forms on the adjacent upland.

A field surrounded by brush and high trees is more frosty than one in the open where slight breezes can stir the air. Wherever possible, therefore, the surrounding land should be cleared for some distance from the edge of the field. If the air circulates freely frost will not occur until the entire air temperature is below freezing. The water drainage outlet must be lower than the cranberry field, and frequently much can be done to prevent frost by cutting all undergrowth and trees along this outlet for a considerable distance. Cold air can then flow away and lessen the danger of frost.

After all possible frost protection has been given cranberry fields by sanding and by facilitating air movement, summer flooding may be resorted to when necessary. Many growers have a limited supply of water and must conserve it carefully. Most growers wish to flood for frost as little as possible, either because they feel that flooding does some harm, or because they may need the water to control insects, or because flooding in the fall interferes with picking.

It rarely is necessary to cover the vines entirely in flooding for frost. A depth of 1 to 3 inches of water over the sand is enough for this protection except in very severe frosts, as the water will warm the air enough by radiation to keep the vines from freezing.

WEATHER FORECASTING.

General knowledge of weather forecasting is very helpful, and as far as possible the forecasting methods of the United States Weather Bureau should be understood.

The Weather Bureau has established a special service for cranberry growing during periods when frosts are likely to occur. This service consists of—

Daily weather maps, available to all applying for them.

Special warnings by wire from the district office nearest each cranberry-growing region, given during danger periods when severe frosts are expected. These are valuable, but as the forecasts are made 15 to 21 hours before the lowest temperatures occur and as unforeseen changes often occur during this time, supplementary service has been developed.

The cranberry substation of the Massachusetts Agricultural Experiment Station at East Wareham, Mass., is in touch with the district Weather Bureau office at Boston and is equipped with all necessary weather instruments. Forecasts during danger periods can be secured by growers from this office at any time of the day or evening. Because the predictions are made at a time so near the danger period, few unforeseen changes occur, and the forecasts are thus more dependable than those made early in the day.

Each cranberry grower should possess several accurate registering minimum thermometers and by their use determine what parts of his field are the coldest; after which the instruments should be kept in those locations, being placed among the vines about 4 inches above the ground.

If the sky is cloudy no frost will occur in late spring and early fall, even though other conditions favor it. It should not be taken for granted, however, in case it is cloudy in the early evening that it will remain so through the night. The clouds may suddenly clear away, the temperature drop quickly, and a damaging frost occur. Under such conditions a watch should be kept throughout the night to flood for frost protection if necessary.

FERTILIZERS.

Most cultivated plants have root hairs which take up both water and plant foods in solution from the soil. The cranberry plant has no root hairs but a mass of fibrous rootlets through which it must secure water and plant foods; but it is evident that this must be done in a manner different from that of ordinary crop plants. It is thought that certain fungi called "mycorrhiza," associated with the roots, have some function connected with the nutrition of the vines.

At present it is only by making tests of different fertilizers on each field that the plant-food needs of the soil can be determined, and until the need has been proved no general use of fertilizers should be practiced. The application of fertilizers on most cranberry fields with deep peat bottoms is not advisable, for they generally fail to increase yields, and the nitrates hurt the keeping quality of the fruit. Certain fertilizers have increased the yields on fields with sand bottoms.

The following paragraphs state the little that is known of the response of the cranberry to fertilizers.

Experiments and experience seem to show that on deep peat areas plenty of nitrogen is available for the cranberry. Often, in fact, there is so much that it causes an excessive vine growth.

Stable manure is undesirable because it spreads weed seed and has other injurious effects.

Sulphate of ammonia has been found injurious to cranberries, probably because of the sulphur in it, and therefore it can not be used as a source of nitrogen. Pure sulphur will kill cranberries if applied in quantity. Sulphuric acid sprayed on one area to kill weeds so affected it that cranberries would not grow for at least six years.

Nitrate of soda applied to cranberry fields stimulates vine growth. On soils called " hard bottoms," which contain a small percentage of muck, it also tends to increase yields. It is doubtful whether any application of nitrate of soda should exceed 150 pounds to the acre, and such an application should be made only to hard-bottomed areas where careful tests indicate its value. Dried blood has also proved a valuable source of nitrogen. Slightly larger quantities are used than of nitrate of soda.

Acid phosphate has been found beneficial on hard bottoms. On such soils it stimulates a good vine growth and heavy fruit production. Raw rock phosphate, where it has been used in Wisconsin, has proved even better than acid phosphate. In that State it is commonly used on hard bottoms. Of acid phosphate 400 pounds or 1 to 1½ tons of raw rock phosphate per acre are commonly used. Muck soils are usually lacking in this plant-food constituent, but may not be benefited by applications of it. No appreciable benefit from its use over a period of years was secured on muck soils at the cranberry substation of the Massachusetts Agricultural Experiment Station.

Potash has not produced enough favorable results on any of the cranberry soils to warrant its use.

The New Jersey Agricultural Experiment Station has recommended the following mixture per acre for gray sand or savanna lands in that State, and considerable success has followed its use:

Sodium nitrate	75 pounds.
Dried blood	75 pounds.
Rock phosphate	300 pounds.
Sulphate of potash	50 pounds.

WEEDING.

Over a hundred species of weeds infest cranberry fields, including most plants that live on peat and lowland meadows, many being serious pests. The annual cost of weeding some fields reaches $100 an acre, but $5 to $10 ought to do this work if the field is properly made in the first place and properly cared for until it comes into bearing.

The easiest way to control weeds on many fields is to keep them from becoming established. Field after field has been noted where seed trees were standing along shores or dikes. In a circle extending from 50 to several hundred feet from such trees, seedlings could be seen which were costing many dollars each year to eradicate, besides damaging the cranberries. In one field, hundreds of young black-gum seedlings were near an old tree that could have been destroyed in a few minutes, and in other fields young cedars, birches, maples, and various trees have been seen covering large areas, while near by on the shore were a few or solitary seed-bearing trees. The upland for some distance back from cranberry fields should be kept clean.

Another way in which many growers could save much money now spent in weeding is by keeping shore ditches and ditches along dams clean, so as to prevent the spread of shrubby plants to the cranberry fields. Bayberry, huckleberry, blueberry, leatherleaf, aronia, willows, poison-ivy, greenbrier, swamp dewberry, and some other weeds often enter cranberry fields by means of stolons or rhizomes from surrounding uplands or dikes.

All annual or biennial grasses and weeds can be controlled easily by mowing just before their seed matures. If all infested fields are so mowed and the surrounding upland kept clean no trouble from these need be experienced.

Good drainage greatly discourages the growth of most weeds which infest cranberry fields, at the same time favoring the development of the cranberry, and a vigorous growth of vines will smother many weeds.

Some weeds can be killed by spraying with materials that will not injure the cranberry vines. Iron-sulphate spray, made by dissolving 100 pounds of iron sulphate in 50 gallons of water, is used in Wisconsin to kill ferns, wood moss, many sedges, and other weeds. Two to three applications of this material made 10 days to two weeks apart will kill the aboveground parts and finally the roots. Cranberry fields should not be sprayed when in bloom or when the terminal buds have just opened. To make the applications effective a strong pressure must be maintained when spraying. Only brass-lined spray pumps should be used for this purpose. In Massachusetts dry iron sulphate sifted around the roots of ferns will kill them, but in New Jersey this treatment has not proved effective.

Most " weed killers " contain sodium arsenite and are used for destroying all vegetation along paths, driveways, etc. Sodium arsenite will injure cranberry vines when used at a strength effective for weeds, and it is not recommended for general use in cranberry fields. However, if areas are very weedy it may pay better to spray with a weed killer and later replant than to scalp and replant.

Sulphuric acid is used by some growers to kill greenbrier and ferns. This acid also injures cranberry vines; therefore a copper can with a long narrow spout through which only a little acid can come at a time is used to apply it. Men go through infested fields with such cans, letting a few drops run down the stem of each weed. This must be repeated at intervals during the summer until all are killed.

Some weeds can be killed most readily by drowning. To do this the winter flooding must be continued till July 10 or 15. If the water is then drained off, the vines will grow and bud for the next year's cranberries, thus losing but one year's crop. By this treatment most of the grasses and weeds are killed, though some survive and must be eradicated by other means.

In Wisconsin sedges and grasses are especially troublesome, and flooding is done to drown them out. To make the drowning more effective, the weeds are mowed while flooded, so that no tops may rise above the surface of the water. In some cases a shallow flood about 6 inches deep is held until July 10 to 15, and a roller is run over

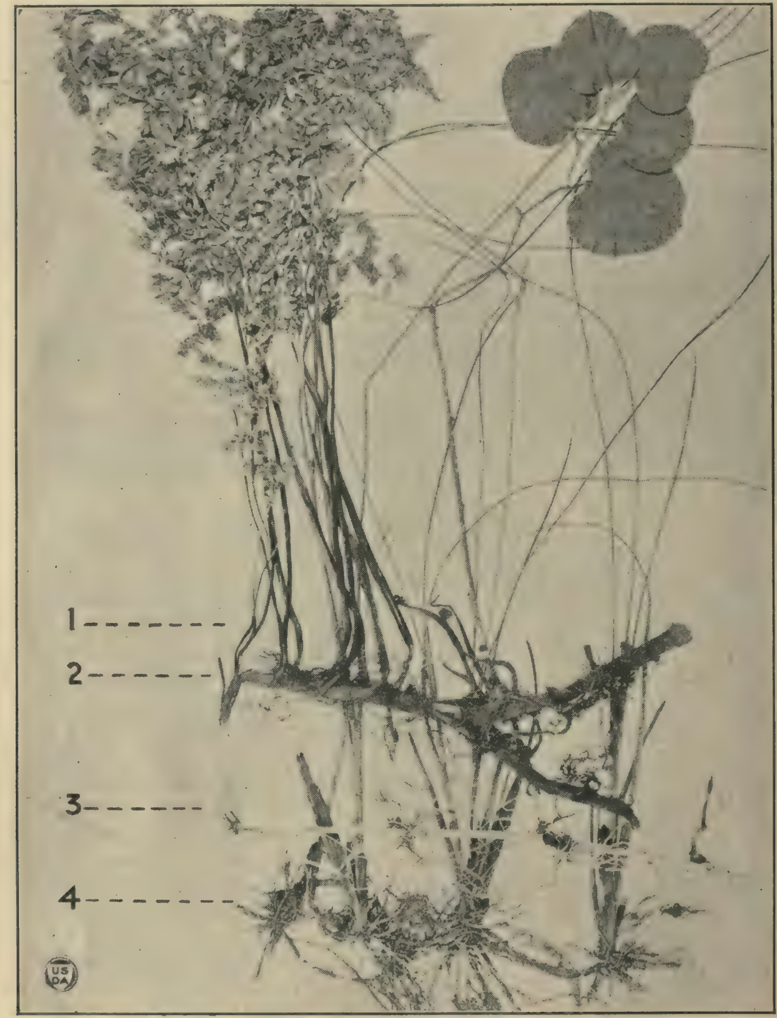

FIG. 1.—Weeds of cranberry fields. The illustration shows the position of weed roots in the soil. The surface of the soil line is represented at *1*. The root of the chain fern (*Woodwardia virginica*), which occupies the same soil layer as the cranberry root is shown at *2*. Weeds whose roots occupy this soil layer either crowd out the cranberry or are crowded out by it. The root of the greenbrier (*Smilax rotundifolia*) is shown at *3*. It occupies the soil layer just below that occupied by the cranberry roots. The root of three-square (*Scirpus americanus*) is shown at *4*. It occupies a still lower soil layer. All weeds whose roots occupy the soil layers below the cranberry root can crowd out the cranberry if their tops rise above the cranberry vines. They must be eradicated.

the grasses at frequent intervals to break them over into the water and check their growth.

In general, there are three layers of weed roots in soils of cranberry fields, as illustrated by Figure 1. The root at the top is that of the fern, which occupies the same layer of soil as the cranberry roots. Next below the root of the fern is shown that of the greenbrier, which grows in the layer of soil just below that which the cranberry roots occupy. When fields are badly infested with the greenbrier, so completely is the soil layer filled by its roots that it is even possible to roll up the turf by pulling on a mass of greenbrier roots. Below the roots of greenbrier are the roots of the three-square. All these plants can flourish on the same area, and all may infest the same part of a cranberry field.

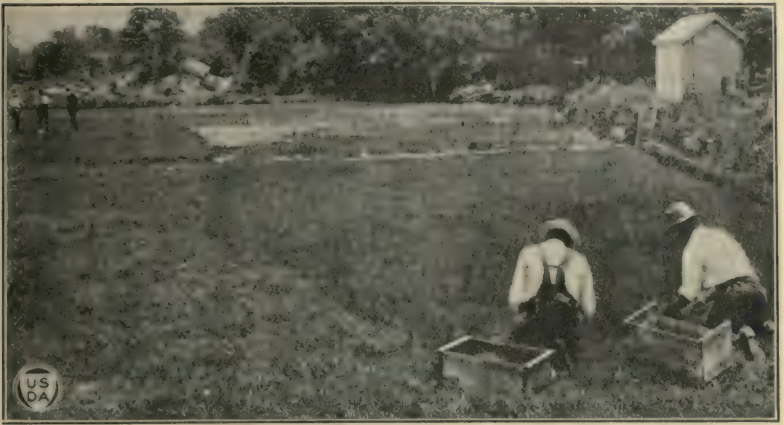

FIG. 2.—Weeding a cranberry field at East Wareham, Mass. Many weeds are pulled by the roots and carried off in baskets or boxes. Photographed June 21.

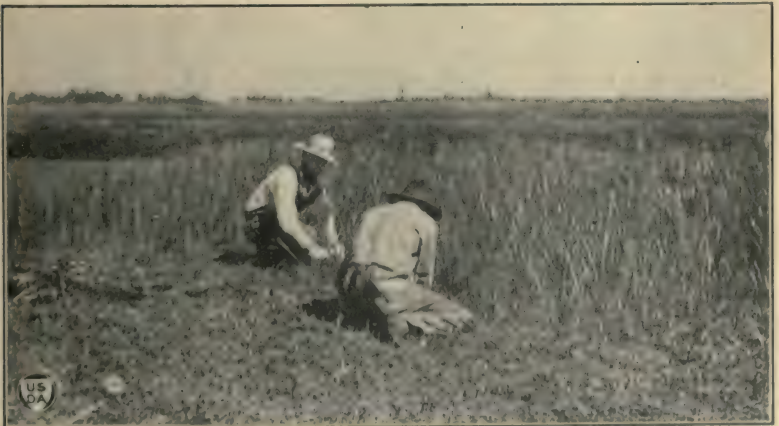

FIG. 3.—Weeding in a Wisconsin cranberry field.

Weeds with root systems in the same soil layer with the cranberry roots will finally crowd out the cranberry or be crowded out by it.

Ferns grow higher than the cranberry and shade it. If permitted to grow they finally weaken and crowd out the crop. Certain other weeds, such as the violet, have roots in the cranberry soil layer, but their tops are so low that they are shaded out by the cranberry vines. Ferns and other tall weeds, therefore, must be cleaned out, while no attention need be paid to the violet.

Most cranberry weeding is done in the manner illustrated in Figures 2 and 3. Men go over the whole field and grub out the weeds, using the tools shown in Figure 4. It is best each season to complete the weeding before the cranberry blossoms, but this is often impossible, and weeding is continued into midsummer. Weeding can not be economically done after harvesting, as the weeds are trampled down and it is not easy to separate them from the vines.

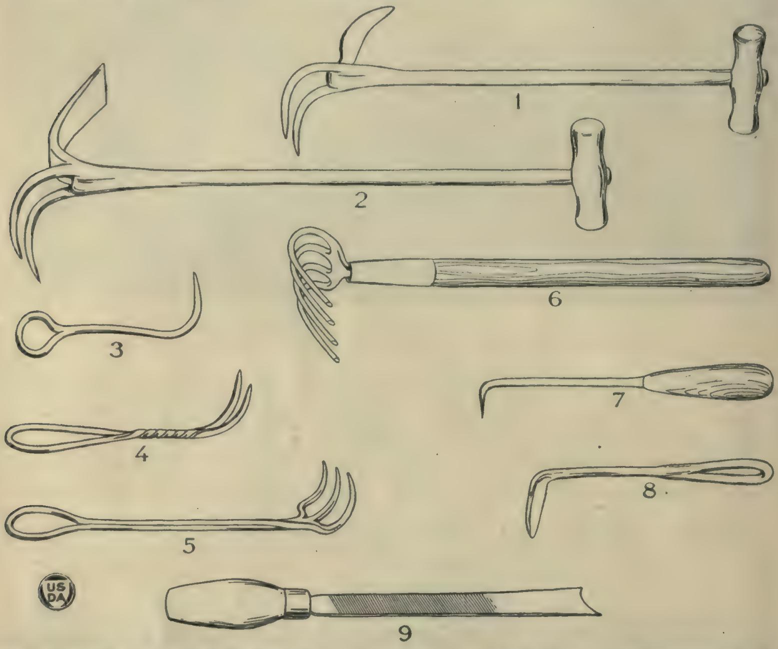

FIG. 4.—Types of hand weeders used in cranberry fields: *1*, A 2-pronged weeder with a narrow-pointed blade on the side opposite the prongs; used in New Jersey. *2*, A weeder similar to *1* except that the blade is flattened instead of being pointed; used in New Jersey. *3*, A 1-pronged weeder or hook used on Long Island; preferred where the vines are thick and small weeds abound. *4* and *5*, Weeders used on Long Island; preferred where the vines are not crowded close together and where large weeds occur. *6*, A 4-tined weeder used where the weeds are large; Massachusetts. *7*, A 1-pronged weeder or hook used in Wisconsin in cases where the vines are thick and small weeds are numerous. *8*, A weeder with sharpened blade used in Massachusetts. *9*, A weeder made from an old file; the end is sharpened and the edge curved to prevent weeds with hard stems from slipping off sidewise; used in Wisconsin. These weeders vary in length from 8 or 10 inches to about 2 feet.

Brief comments on the nature and control of many of the more important weeds follow.

Algæ.—These form the growth commonly called "green scum." It is especially troublesome on fields where the winter flood is held late to control the fruit worm and other pests and in the flooding of the fields with numerous springs in the bottom. Suspending a sack containing copper sulphate in the water at the source of supply, as is done in controlling algæ in city water reservoirs, is suggested. Frequent changing of the flood water, where possible, helps to control this trouble.

Bayberry (*Myrica carolinensis*).—A well-known shrub bearing minute bony nuts. Rarely a weed except in New Jersey fields. Spreads as does the chokeberry and is controlled in the same way.

Birch (*Betula populifolia*).—A weed, chiefly in Massachusetts and New Jersey, where seed trees are allowed to grow on near-by upland. Cut out seed trees and pull seedlings in fields. (Fig. 5.)

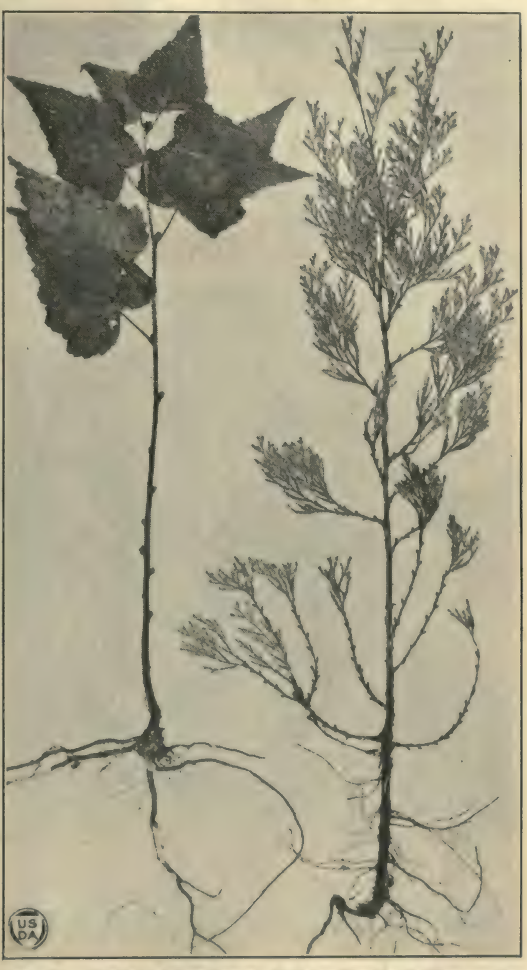

FIG. 5.—Weeds of cranberry fields. To the left a young birch, to the right a young cedar, both pulled from a cranberry field. The root systems of these trees occupy the soil layer below the cranberry root. These trees neither sucker nor have underground rootstocks and if pulled are killed. Seed trees of these species and others, such as black or sour gum and maples, along dams and borders should be cut to stop the seed from scattering to the cranberry field.

Chokeberry (*Aronia arbutifolia*, *A. melanocarpa*).—Shrubs bearing either scarlet, purplish, or black fruit. Rarely weeds in Wisconsin and Massachusetts, but common in New Jersey fields. Spreads by underground stems and by seeds. Seedlings easily rooted out when they first start, but difficult to eradicate later. Keeping border ditches well cleaned out will prevent the establishment of chokeberries along the edges of the field.

Clover (*Trifolium fimbriatum*).—A perennial clover sending out underground runners in all directions. It is found on the Pacific coast, and in that section is one of the worst weeds of cranberry fields. Underground stems may extend several feet before appearing above ground. This makes the work of digging it out especially difficult, as any piece left may start a new plant.

Dewberry, or running brier (*Rubus hispidus and its hybrids*).—A swamp dewberry with very long canes which root at the tips. It is a serious weed in New Jersey, and often in Massachusetts and Wisconsin. It almost always spreads from adjoining upland into cranberry fields, but may easily be kept out by keeping border ditches clean. It is readily killed by holding the flood late in spring.

Ferns.—Several kinds of fern are common in cranberry fields and often become serious weeds. The chain fern, also called brake and bracken in New Jersey (*Woodwardia virginica*), shown in Figure 6, is the worst of all ferns. Its creeping rootstock grows in the same soil layer as the cranberry roots. In Massachusetts it is controlled by placing dry iron sulphate around the roots, and in New Jersey by the use of sulphuric acid. This fern grows much more rankly in New Jersey than in Massachusetts. In Wisconsin, spots densely covered with it may be trampled down and immediately sprayed with iron-sulphate solution or dusted with the sulphate in the powdered form. In that State ferns may also be controlled by mowing regularly every two weeks for one or two seasons.

Bracken (*Pteridium latiusculum, formerly known as Pteris aquilina*).—Often troublesome on dry fields in Massachusetts. It yields to frequent mowing.

Five-leaf or yellow avens (*Geum strictum*).—This spreads by means of an underground rootstock much like the brakes, and its 5-parted leaves shade the cranberry vine. It is controlled in the same way as the bracken.

Grasses.—Many kinds of grasses are occasional weeds in cranberry fields, usually spreading by seed from the surrounding upland. Winter flooding is a sufficient control for most grasses. Rice cut-grass (*Homalocenchrus oryzoides*) among the grasses is the most common and persistent cranberry weed. Good drainage is its best control. The rattlesnake grass (*Panicularia canadensis*) is troublesome and grows rapidly, spreading from seed and underground rootstocks. Frequent mowing early in the season will check it. Spraying with iron-sulphate solution also helps to hold it in check in Wisconsin.

Greenbriers (*Smilax rotundifolia, Smilax glauca*).—These are also called cat briers or horse briers (fig. 7), and are among the most serious weeds of cranberry fields. They have a deep underground rootstock which may send up a stem at each node (joint), and in eradication every node must be taken out or they will grow again. Badly infested areas are commonly scalped, cleaned, and reset. Persistent use of sulphuric acid, as described on page 7, will eventually kill the plants.

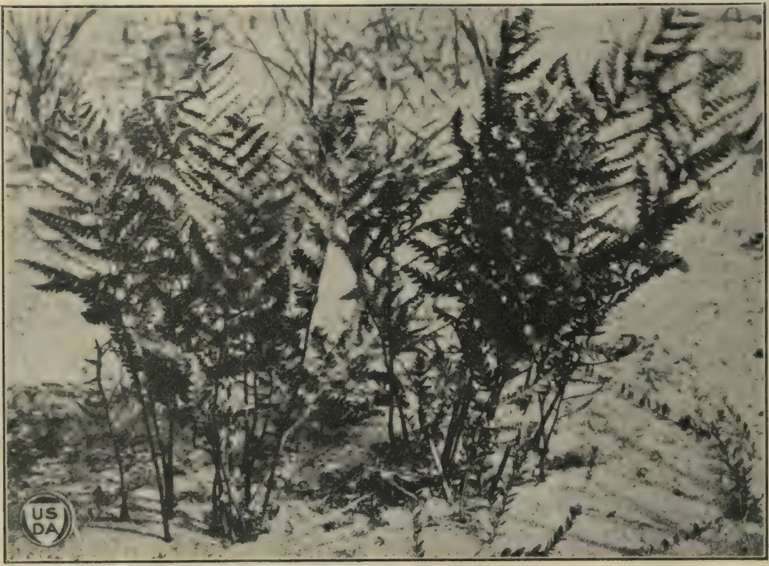

FIG. 6.—Chain fern (*Woodwardia virginica*), one of the worst cranberry weeds in parts of New Jersey; also common in Massachusetts and Wisconsin. Its roots occupy the same layer of soil as the cranberry roots, and it spreads rapidly. In Massachusetts it is treated effectively by sifting dry iron sulphate around the bases of the plants. Treatment with sulphuric acid is considered necessary in New Jersey.

Horsetails (*Equisetum sp.*).—The horsetails have perennial wide-spreading rootstocks. They sometimes infest cranberry fields and are hard to eradicate because of the great vitality of their rootstocks. In Wisconsin repeated spraying every 10 days with iron-sulphate solution has been effective in controlling this type of weed. In that State, after persisting for a few years, dense patches may disappear suddenly. If a new planting is much infested with horsetails it should be hoed over once a week regularly until the weeds are killed out and then be replanted. It is better to disregard it in old fields.

Leatherleaf or Cassandra (*Chamaedaphne calyculata*).—A low shrub controlled by grubbing.

Mosses.—Sphagnum moss is not serious except on fields kept too wet. Such fields should be better drained. In Wisconsin 10 pounds of quicklime in 50 gallons of water sprayed twice during the growing season will control this moss on wet fields. Wood moss also is rarely a serious weed except on wet areas in Wisconsin. There it may be controlled by three applications, made 10 days apart, of a salt spray consisting of 1 pound of salt to 3 gallons of water, or by covering with sand, or by spraying with iron-sulphate solution shortly after growth starts in the spring before the cranberry buds have opened. Nitrate of soda used at the rate of 150 pounds per acre reduces this moss and promotes cranberry vine growth at the same time.

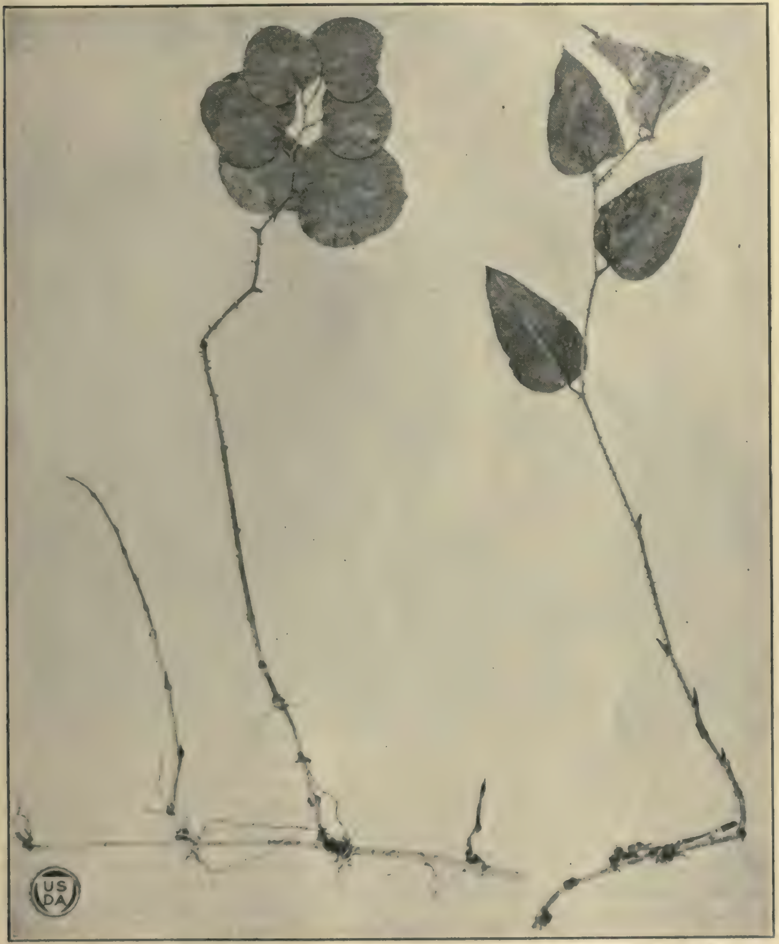

FIG. 7.—Greenbrier, cat brier, or horse brier. To the left is the round-leafed greenbrier (*Smilax rotundifolia*); to the right the lance-leafed form (*S. glauca*). Both are bad weeds in cranberry fields and are controlled by digging out the roots or by continued treatment with sulphuric acid.

Poison ivy (*Rhus toxicodendron*).—This is seldom a serious weed in cranberry fields except in New Jersey, and there it is serious mainly because it poisons the pickers and other workers. It spreads by means of underground rootstocks, mostly from neighboring upland. If border ditches are kept clean little trouble will be experienced, but if established it must be grubbed out or killed with sulphuric acid.

Redroot or dyeweed (*Gyrotheca tinctoria*).—This perennial herb has been considered a serious weed of cranberry fields in New Jersey because of its wide-spreading rootstocks which make new plants. Vigorous-growing cranberry vines, however, will crowd it out, and under ordinarily good conditions it is not troublesome. Pulling has been the common method of control (fig. 8). Golden-crest (*Lophiola americana*) resembles redroot and its control is the same.

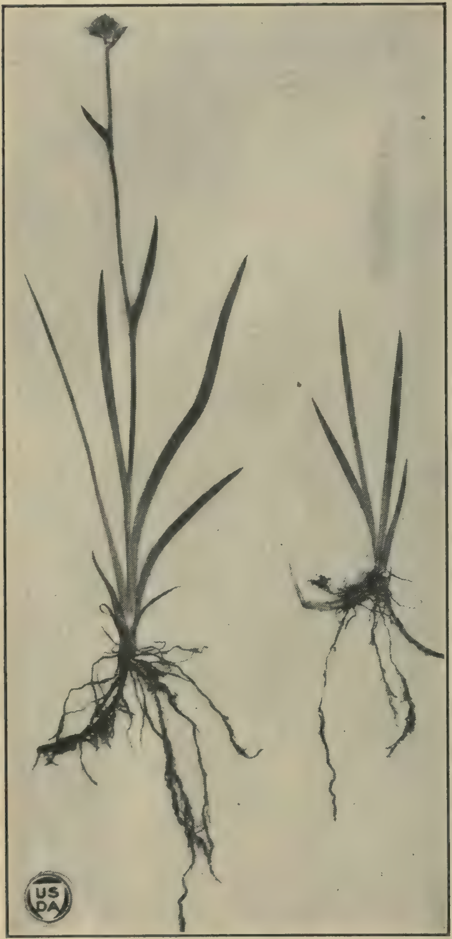

FIG. 8.—Redroot (*Gyrotheca tinctoria*), a serious weed in New Jersey. It is now believed that by giving the cranberry vines the best of care this weed will be crowded out.

Sedges and rushes.—Many kinds of sedges and rushes grow in cranberry fields, some of them being among the most serious of the weeds. Cotton grass (*Eriophorum virginicum*) and three-square (*Scirpus americanus*) are among the most troublesome. They spread by seed and to some extent also by underground rootstocks (fig. 9). The roots and rootstocks of some species occupy a soil layer lower than that occupied by the cranberry root system. Many can be completely eradicated only by digging, but good drainage and mowing always help. Wisconsin growers sometimes kill out certain of these plants by holding the flood late and mowing under the water such growth as appears.

Among the more serious sedges and rushes are the following: Dulichium, star-grass, or leafy sedge (*Dulichium arundinaceum*) is a weed that spreads by seeds and underground rootstocks, becoming very dense in spots. Drainage is essential to its control. Frequent mowing or pulling is effective in checking its spread. In Wisconsin spraying with iron-sulphate solution in the early part of the season will hold it in check, while the growth on badly infested areas may be trampled down and immediately sprayed with the iron-sulphate solution or dusted with the powdered form. Bog rushes (several species of Juncus, especially *Juncus canadensis*) are very common on sanded fields and spread rapidly. They should be mowed above the vines to prevent seeding until the latter crowd them out. Good drainage helps to control them, and in Wisconsin iron-sulphate sprays applied at 10-day intervals during the early part of the season help to check their growth. Bunch-grass, leafy bulrush, or bull grass (*Scirpus polyphyllus*) is a rank-growing perennial sedge with slender stalks. Young plants are easily pulled, but well-established plants must be cut out with an adz, or with a special 3-cornered hoe made by cutting away parts of the blade of a large garden hoe and sharpening the edges. Cut-grass (*Carex bullata*) propagates by seeds and coarse rootstocks, and the growth may become very dense. The leaves are coarse and their edges cut the hands of pickers, who dislike to harvest the crop where it is present. Large, badly infested areas should be rescalped. Small infested areas should be drained and may be weeded by using one of the tools shown in Figure 4. Frequent mowing in the early part of the season will hold it in check. Three-square (*Scirpus americanus;* fig. 7) is one of the sedges which propagates by seeds and rootstocks. Its control is the same as for Dulichium, or star-grass. Virginia cotton grass (*Eriophorum virginicum*) is a wet-land plant which propagates by seeds and underground rootstocks, producing large tufts of cottony seed masses in the fall. After the seed masses have been blown off the leaves turn a reddish brown. Its control is the same as for Dulichium, or star-grass. Wire-grass (*Carex oligosperma*) is a common weed of unsanded or poorly drained peat fields. Pulling is hardly practicable, but drainage is essential. One to three mowings just above the cranberry vines in early summer prevent it from seeding and check it so that vigorous vines will crowd it out. Along the ditches it is controlled by frequent pulling or mowing until the vines are well established. If necessary, the edge of the ditch can then be cut off to remove the grass.

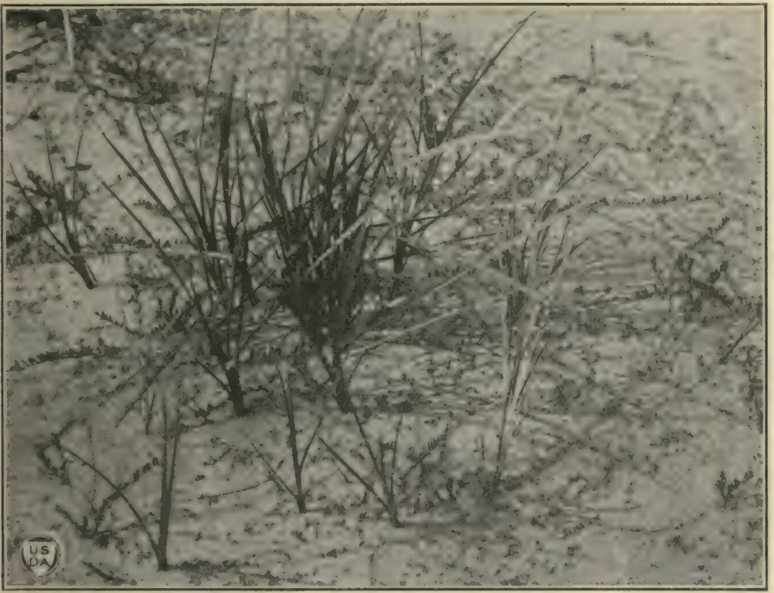

FIG. 9.—Sedges in a cranberry field, showing the young plants which have grown from the original plant in the center. Sedges crowd and shade the cranberry vines, and their roots grow in a soil layer below that which the cranberry roots occupy. They are more common on fields kept too wet than elsewhere, and they are often controlled by draining.

Sweet fern (*Comptonia peregrina; also known as Myrica asplenifolia*).—Occasionally a serious weed in New Jersey. It is controlled by grubbing.

Three-leaf bogbean (*Menyanthes trifoliata*).—A Wisconsin weed. The wide-spreading thick leaves on coarse runners shade and crowd the cranberry vines. Treatment as for Dulichium, or star-grass, is recommended.

White cedar (*Chamaecyparis thyoides*).—A weed chiefly in New Jersey where seed trees are allowed to grow on near-by land. Cut out seed trees and pull seedlings in the field. (See fig. 5.) Seedlings are easy to pull the first season.

Willows.—In Wisconsin fields certain willows become serious weeds if not pulled out when they first appear (fig. 10).

CLEANING DITCHES AND UPLAND.

Every few years all ditches must be cleaned. Sand and mud wash into them and growing weeds help to fill them, thus impairing the drainage.

To protect the field against forest fires, to destroy weeds, and to make picking more convenient, the adjacent upland should be mowed each year.

PRUNING.

Cranberry vines are pruned to cut runners that might interfere with scooping, and sometimes to thin out vines. Under ideal conditions on established fields the uprights make an annual growth of 1 to 3 inches. Full crops may then be produced and little or no pruning is necessary. Maximum pruning is needed on fields with rich bottoms where long runners abound.

The first pruning should be done after the first picking with scoops. The vines grow in all directions, and to avoid pulling many vines loose this first crop should be harvested with a picking device called a "snap," though in Wisconsin it is nearly always hand picked. To make it possible to use snaps and scoops easily thereafter without damage to the plants cross runners should be cut, and all those not cut should run in one direction—that in which the pickers must thereafter go when scooping. Loose vines are first raked off the field, as shown in Figure 11. Pruners follow after those raking the loose vines.

Figure 12 shows the type of pruning rake commonly used. Horserakes with knife teeth are occasionally used; but careful work can not be done with them.

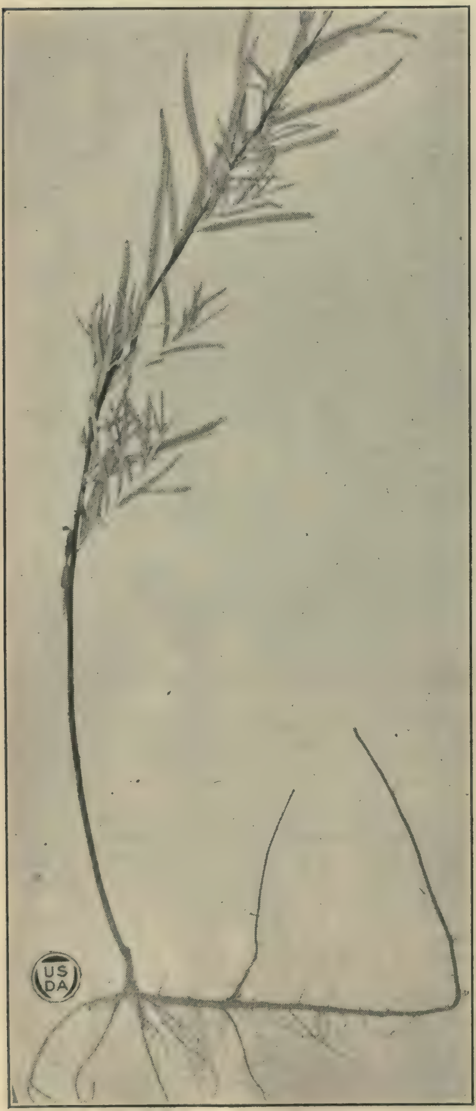

FIG. 10.—A willow seedling (*Salix interior*). This is often a serious shrub in Wisconsin cranberry fields and must be grubbed out.

MOWING AND BURNING.

Sometimes the vines become dense, clumpy, and tangled. Growers often burn or mow such areas in the dormant season.

Burning may be more economical, but mowing probably is preferable. A fair crop often is secured the second year after mowing, and the third year a full crop may be expected.

Figure 13 shows an area where too rapid growth has been made and the uprights are 18 to 24 inches long. Little fruit is produced under these conditions. This area should be mowed.

When areas become badly infested with certain insect pests, growers sometimes feel that it pays to renew all the vine growth by burning, at the same time destroying the insects. The burning is done from November to April, inclusive, either with the ground frozen or with the water table at the surface. Burning should not be done when the ground is dry, for it may kill the cranberry roots. A full crop is expected the third year after burning.

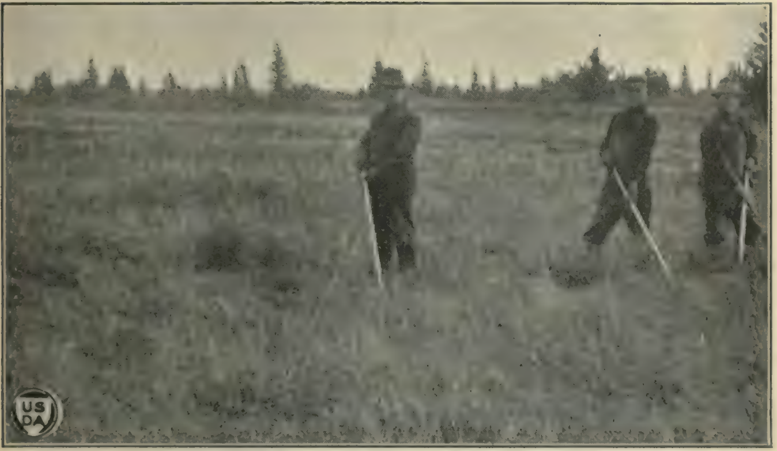

FIG. 11.—Raking off torn and broken vines after harvesting. Photographed October 13, 1917, at Walker, Wis.

DURATION OF A CRANBERRY FIELD.

Properly constructed fields are practically permanent. Only because of injury by insects, by winterkilling, or in some other way do they ever need to be replanted. Growers sometimes scalp and replant fields that were planted to unprofitable varieties, but they rarely replant profitable areas. The cost of replanting a field and caring for it until it comes into bearing is too great to make the practice common. Actual records show that the cost of replanting and again bringing the field into bearing has been $500 to $800 per acre.

Figure 14 shows one of the first fields ever planted. Figure 15 shows another field near by with its first crop being harvested.

SEASONAL OPERATIONS IN CRANBERRY FIELDS.

The operations in a cranberry field may be summarized briefly as follows:

January, February, and March.—Watch the winter flood, letting off water when it becomes too deep and letting it on when too shallow. Repair breaks in dams and dikes. Resand on ice when practicable and when needed.

Clean separators and houses and repair scoops and boxes.

April.—Remove winter flood except where fruit worm is serious. Repair head gates. Resand if it is necessary.

May.—Remove winter flood if this was not done in April. Reflow whenever freezes occur or frosts threaten after growth starts, and in New Jersey reflow to control the blackhead fireworm. Continue repair work. Begin weeding if season is early.

June.—Reflow to control blackhead fireworm and other pests. Do all weeding possible. Spray to control insect pests when it is necessary. Spray in New Jersey for early-rot just before the blossoms open. Mow upland and dams.

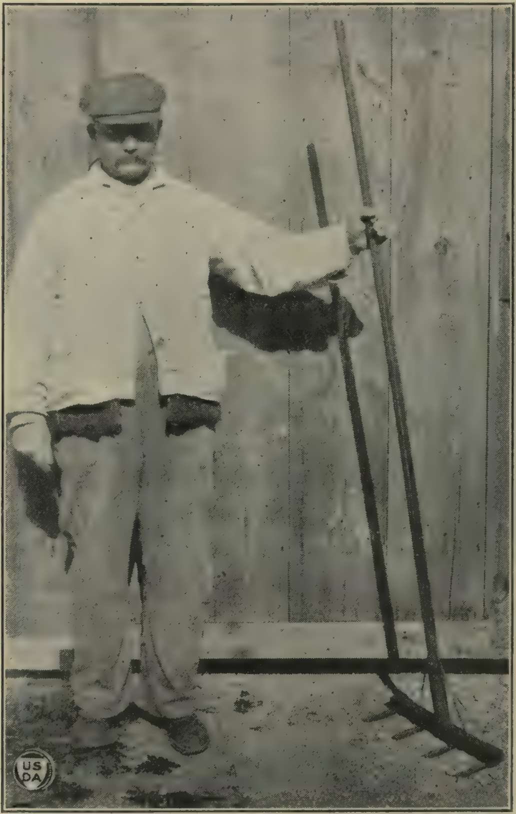

FIG. 12.—Pruning rake used to cut runners in cranberry fields. Knives are used in place of the teeth of an ordinary rake. The runners are cut so that scoops may be used in harvesting. This tool often has been used much too freely.

July.—Apply second spray for early-rot in New Jersey when the blossoms fall, and again two weeks later. Spray to control insect pests when it is necessary. Continue weeding fields and mowing upland.

August.—Overhaul pump engine. Engage pickers and screeners. Improve roadways in preparation for harvest.

September.—Pick all early varieties, beginning early in the month. Flood for frosts only when absolutely necessary. Reflow picked fields for two weeks, starting during the last week of this month.

October.—Pick the late varieties before the middle of the month. After picking rake off loose vines. Prune where necessary. Begin resanding if this is needed where sanding on ice is not practicable.

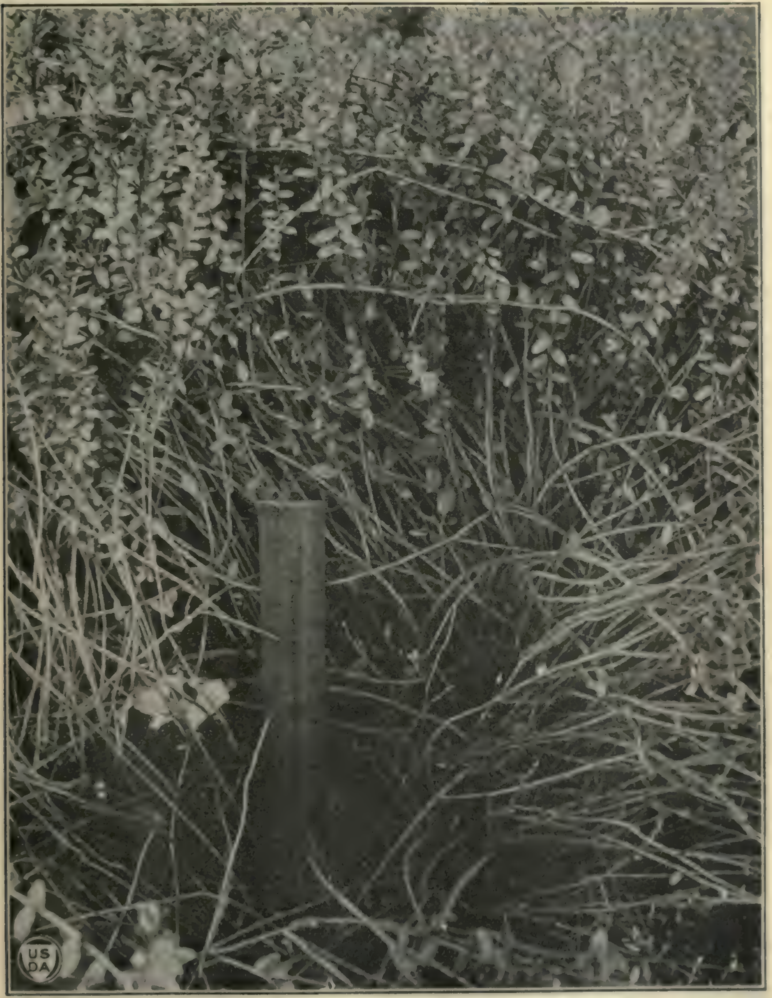

FIG. 13.—Vines of the Howes variety on very rich peat. Note that the uprights much exceed the height of the foot rule. Such areas should be mowed or burned over.

November and December.—Continue resanding. Put on winter flood in Wisconsin from November 15 to 30; in Massachusetts and New Jersey in December.

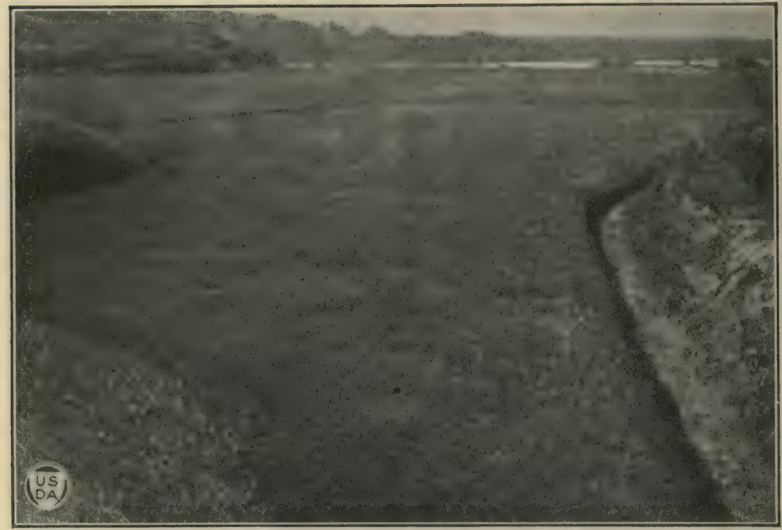

FIG. 14.—A cranberry field, one of the first to be made, still in good condition after bearing for 70 to 80 years. Photographed at Pleasant Lake, Mass., September 27, 1917.

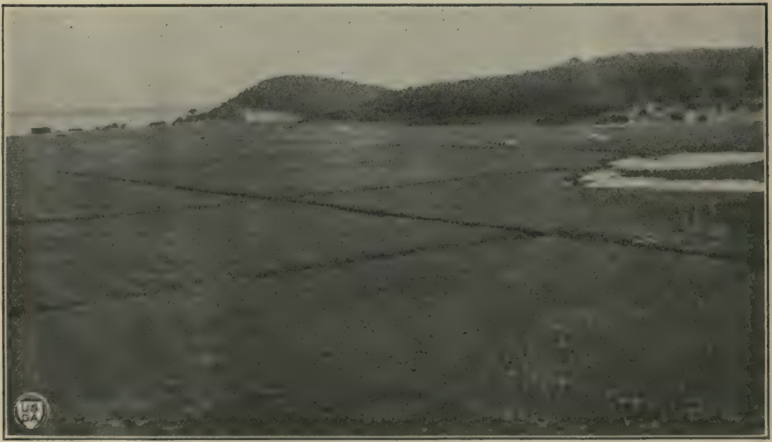

FIG. 15.—New cranberry field at Pleasant Lake, Mass., located near the field shown in Figure 14. Note the sand banks in the background at the left and right. Photographed September 27, 1917.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

November 24, 1923.

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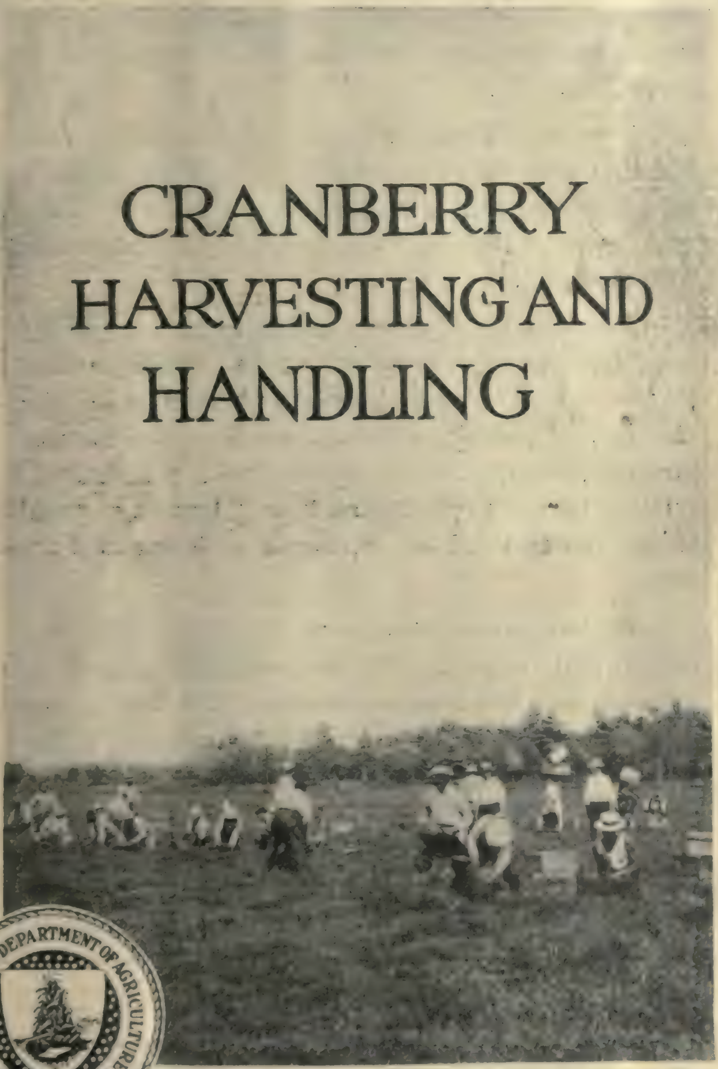
U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1402

CRANBERRY HARVESTING AND HANDLING



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THIS is the third of a series of bulletins on the cranberry. The two preceding bulletins are Farmers' Bulletin 1400, Establishing Cranberry Fields, and Farmers' Bulletin 1401, Managing Cranberry Fields.

Two other bulletins should also be read in conjunction with this: Farmers' Bulletin 860, Cranberry Insect Problems and Suggestions for Solving Them, and Farmers' Bulletin 1081, Cranberry Diseases and Their Control.

In this bulletin approved practices for harvesting, handling, storing, grading, sorting, and packing cranberries are given. Special emphasis is laid on the time of picking different varieties, the time of picking in relation to the date of fall frosts, and the relation between the temperature of berries exposed to the sun and the air temperature throughout the day.

Considerable information is given regarding the objects and methods of the cooperative cranberry organizations. For a more detailed discussion of one of these, the reader is referred to Department Bulletin No. 1109, Sales Methods and Policies of a Growers' National Marketing Agency.

Washington, D. C. Issued April, 1924

CRANBERRY HARVESTING AND HANDLING.[1]

By **HENRY J. FRANKLIN**, *Superintendent of the Cranberry Substation, Massachusetts Agricultural Experiment Station;* **GEORGE M. DARROW**, *Pomologist, Office of Horticultural Investigations, Bureau of Plant Industry;* and **O. G. MALDE**, formerly *Superintendent, Wisconsin Cranberry Experiment Station.*

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IMPORTANCE OF CAREFUL PICKING, HANDLING, AND PACKING IN RELATION TO MARKETING.

IN ORDER TO HARVEST and market a cranberry crop in the best condition it is necessary, first of all, so to construct and manage the field that sound berries are produced. Such fruit, though naturally possessing good keeping qualities, may be spoiled in handling, or it may be so handled that it can be shipped to the most distant market in the United States in good condition. As commonly handled, however, perhaps the loss between field and consumer has been greater with the cranberry than with any other fruit. Losses to the grower start in the field, where ordinarily 5 to 15 per cent and sometimes even 30 per cent of the crop is left by the pickers. A second loss occurs from natural shrinkage of the berries, due mostly to respiration. This shrinkage is slight when the berries are shipped immediately after picking and consumed within a short time, but when the crop is held in storage for some months it may reach 12 per cent. A third loss occurs when, as the result of injury in picking or in handling the boxes of berries, in "screening," and in packing, fungi infect the berries and they decay. Still other losses may occur as the result of freezing and smothering.

Recent investigations have revealed the causes of most of the losses, and the experience of certain growers has shown that many of them can be avoided. The organization of growers into both educational and cooperative selling associations has furnished a means of informing them concerning such losses and the practical means of controlling them. The results of experiments and the experience of growers are presented in the following pages.

---

[1] In Massachusetts and New Jersey the name "bog" is commonly applied to areas planted to cranberries, though very small areas are referred to as "yards." In Wisconsin the word "marsh" is used in place of "bog." The words "bog" and "marsh" both refer to swampy ground. The popular conception of a bog or marsh is a swamp where mosquitoes breed, a nuisance in any neighborhood. Neither term, then, is fitly applied to a developed, well-drained cranberry property. To apply a term in keeping with modern methods of raising cranberries, the term "field" is used in this bulletin, and a properly drained area planted to cranberries is called a "cranberry field."

HARVESTING.

THE HARVESTING SEASON.

In New Jersey picking usually is started about September 1, though sometimes a few days earlier. In Massachusetts it begins a few days later than in New Jersey—not before September 1 or later than September 10.

In Massachusetts the Early Black variety usually should be picked the second week in September, the berries continuing to increase rapidly in size until that time, while previously they are usually too green to be really satisfactory for market. When not picked until late September, this variety becomes overripe and deteriorates seriously in keeping quality.

The Howes variety in Massachusetts keeps better the later it is picked. Harvesting it, therefore, should not start before October 1, and if possible not until the end of the first week in October. At present most of the Howes cranberries are usually picked before October 10.

In Wisconsin picking starts immediately after Labor Day and generally is completed by October 1. Severe frosts occur so frequently after October 1 that picking is difficult and the danger of losing the crop is great. The varieties ripen and are gathered in that State in the following succession: Natives (as the unselected native cranberries are called), Metallic Bell, Prolific, Searl, McFarlin, and Bennett.

HARVESTING SEASON AND FROSTS.

The date of the earliest recorded frost in autumn, the average date of the first frost, and the average date of the end of the harvesting season for each cranberry section are given in Table 1.

TABLE 1.—*Dates of earliest fall frost, average date of first fall frost, and average date of end of harvesting season in each cranberry section.*

Section.	Date of earliest fall frost.	Average date of first fall frost.	Average date of end of harvest season.
Massachusetts	Sept. 2	Sept. 14	Oct. 20
New Jersey	Sept. 22	Oct. 16	[1] Oct. 5
Wisconsin, sanded fields	Aug. 25	Sept. 13	Do.
Wisconsin, without sand	Aug. 8	Aug. 22	Do.
Pacific coast	Nov. 1	Dec. 14	Oct. 1

[1] Though most growers in New Jersey finish picking early in October, a few larger growers do not finish until late in the month.

It will be seen that frosts occur in each section except that on the Pacific coast before harvesting ends. Therefore growers in eastern sections must sometimes protect their crops by flooding. Even a slight injury by frost may cause great trouble and expense, for frosted berries not only must be separated from the sound ones, but unless this is done immediately after the crop is gathered the sound berries become sticky and dirty and their value is greatly impaired.

The fruit on areas least easily protected should be gathered first, other things being equal.

HARVESTING WHEN DRY.

Cranberries should be picked only when they are dry. They should not be gathered while the vines are wet. When a field is flooded to protect against frost, no picking can usually be done the day after the water is removed. Experiments have shown that cranberries picked wet remain so a long time and generally do not keep well.

METHODS OF HARVESTING.

HAND PICKING.

Cranberries were first gathered by hand. In New Jersey many are still hand picked.

Picking tools have been developed and harvesting consequently made easier and more rapid, until now in Massachusetts, on Long Island, and in Wisconsin hand picking is rarely practiced except in the case of young vines and on small areas. On the Pacific coast the McFarlin and Prolific varieties are always hand picked; other sorts are "scooped."

The advantages of hand picking are that when carefully done fewer berries are left in the field and the vines are torn up less than when "scoops" or "rakes" (tools for mechanical picking) are used. But with the acreage now under cultivation the available labor usually is not enough to harvest the crop before frost without using scoops. On the other hand, unless hand pickers are properly supervised the vines and berries are injured more than with scoops. Hand picking also costs more. For these reasons less hand picking is done each year in New Jersey, where the method is still extensively employed. Figure 1 shows a hand picker at work.

Because the roots of young vines are easily torn up in harvesting by the use of scoops, the first crop or two from a new field is commonly picked by hand or with "snaps" (fig. 2), which results in much less injury to the vines than when scoops are used.

HARVESTING WITH SCOOPS OR RAKES.

Figure 3 shows the "scoop," or "rake," commonly used in Wisconsin, and Figure 4 the eastern scoop used in all other sections. Figure 5 shows a group at work with the Wisconsin scoop, and Figure 6 a group using the other type.

Different types of scoops have been developed for different conditions. One type with metal teeth is light and easy to use, but too frail to employ in heavy vines. Another type, very strongly constructed, is excellent for use in heavy vines, but is a little heavy; while a third type, also strongly constructed, has the ends of the teeth flattened, making them harder to pull through the vines.

Because conditions are very variable in fields, the quantity harvested by pickers differs greatly. In Wisconsin good workers harvest 10 to 25 bushels a day, while in Massachusetts 15 to 100 bushels are gathered by good scoopers. Hand pickers gather 2 to 12 bushels a day.

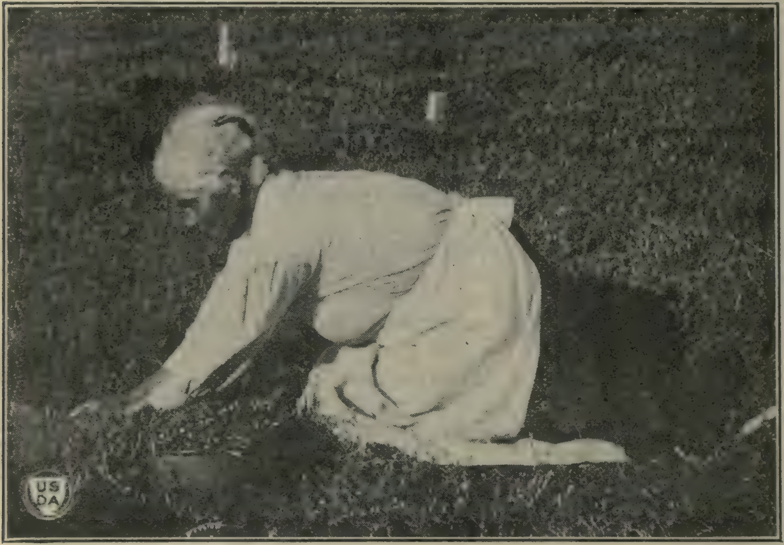

FIG. 1.—Picking cranberries by hand. The first crop produced by young vines should be picked by hand or with "snaps" (fig. 2) to avoid tearing up roots.

In New Jersey the price for hand picking before the war was 50 cents per bushel, and 20 cents per bushel for scooping. In Massachusetts scoopers are commonly hired by the hour, the standard wage for men formerly being from 30 to 35 cents, but during the war rising to 75 cents an hour. In 1921 it was 50 cents. The wage for women runs from 10 to 15 cents per hour less than for men. Scoop-

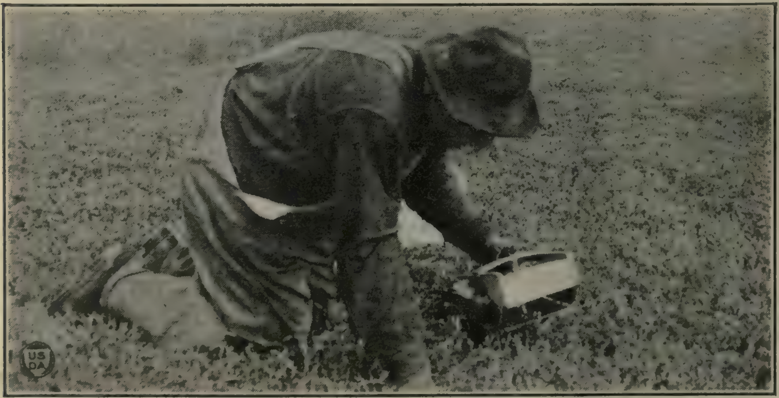

FIG. 2.—A "snap" used for picking cranberries on young loosely rooted vines.

ers paid by the bushel received 20 cents formerly and 30 cents during the war. Hand pickers formerly received 8 cents per 6-quart measure and during the war 12 cents. In Wisconsin hand picking cost 50 cents a bushel before the war and 75 to 85 cents from 1917 to 1920. The scoopers, or rakers, were paid 50 to 60 cents per hour during the latter period and 35 cents before the war.

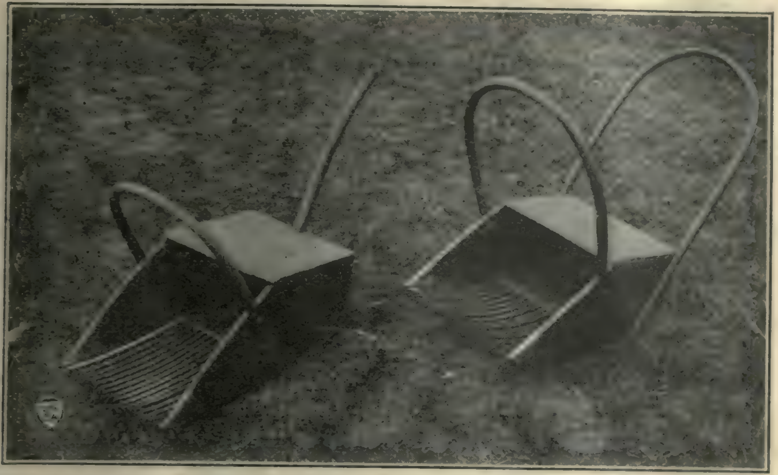

FIG. 3.—Cranberry scoops or rakes used in Wisconsin. The person using this type of implement stands while opertaing it. Compare with Figure 4.

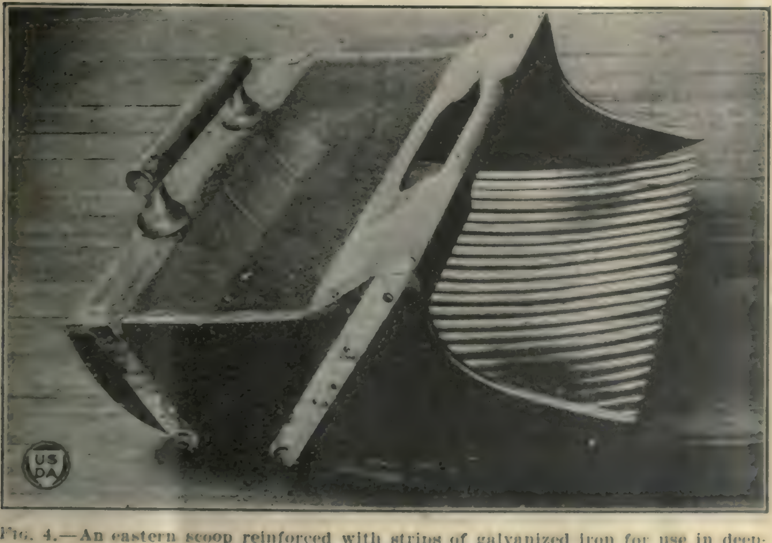

FIG. 4.—An eastern scoop reinforced with strips of galvanized iron for use in deep-tangled cranberry vines.

HARVESTING MACHINES.

Many attempts to invent a harvesting machine have been made in the past 20 years in each of the three main cranberry-growing regions. In recent years special efforts have been made, and a promising machine has at last been produced (fig. 7). If this proves generally satisfactory, it is obvious that growers having smooth fields which can be picked by machine will have a decided advantage over others.

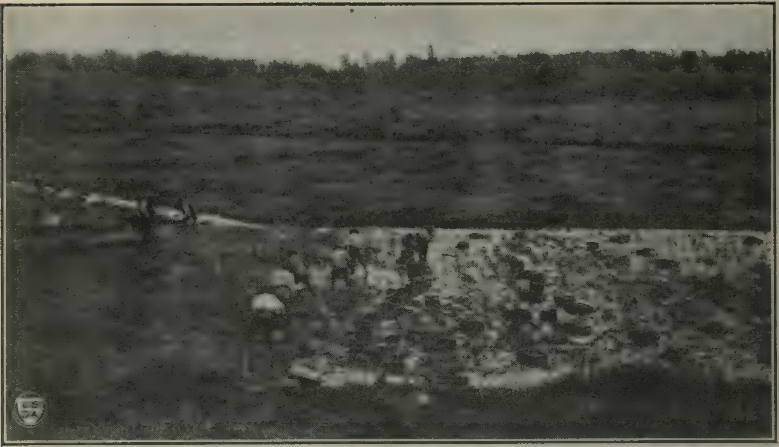

FIG. 5.—Harvesting cranberries with the Wisconsin scoop or rake. In using this type of scoop the pickers stand instead of working on the knees, as shown in Figure 6. Beaver Brook, Wis.

SCOOPING "ON THE FLOOD" COMPARED WITH DRY SCOOPING.

In Wisconsin, though the greater part of the crop is picked dry, some growers flood their fields and scoop "on the flood," but this practice is gradually being given up. When this method is employed the crop is harvested very quickly, a larger percentage of the berries are gathered, the vines are injured less than by other

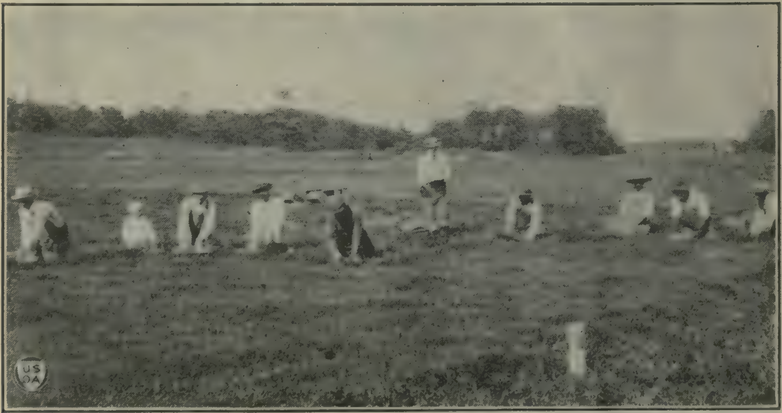

FIG. 6.—Cranberry pickers with the type of scoop used in all sections except Wisconsin. Note that those using the scoop kneel rather than stand. East Wareham, Mass.

methods, and berries can be harvested from young fields with the least injury to the vines. If drying winds prevail, so that the berries dry within a few hours after harvesting, they may keep as well as those scooped dry. If a few days of rainy or cloudy weather occur after picking, however, the keeping quality of the berries is seriously impaired, and the entire crop may soon spoil. Also, if fruit worms have worked in the field, the infested berries will fill with water when flooding is done. Fruit scooped "on the flood" under these conditions is very hard to dry.

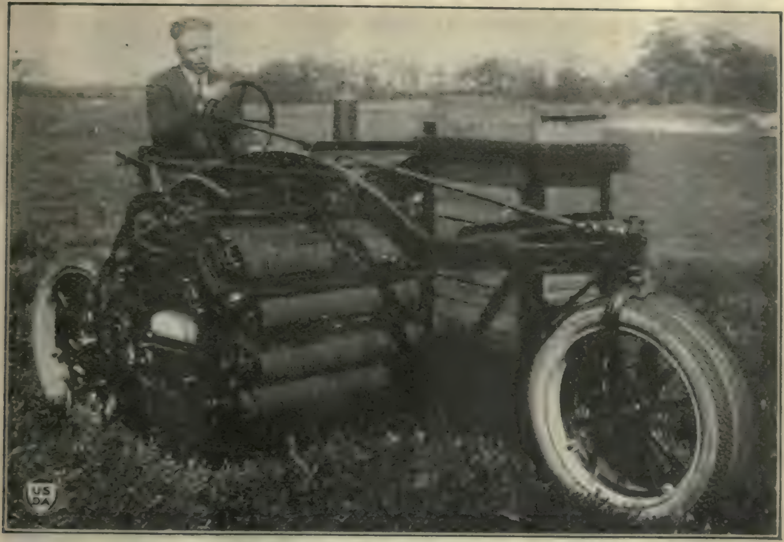

FIG. 7.—A cranberry-picking machine recently developed for conditions in Massachusetts fields.

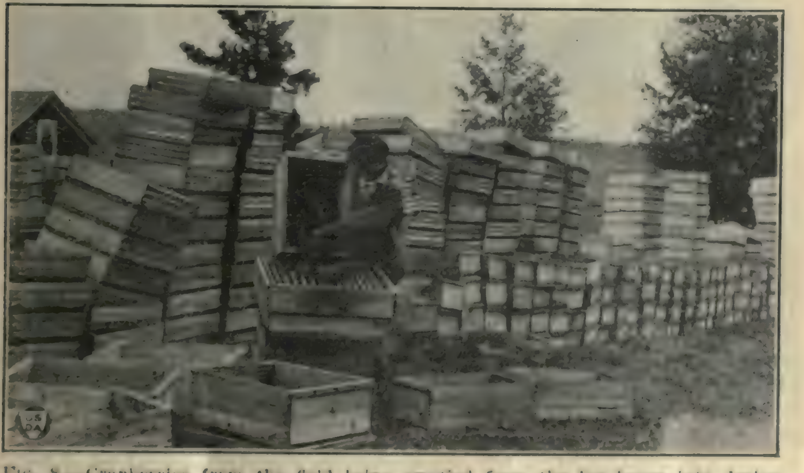

FIG. 8.—Cranberries from the field being emptied from the lug boxes into drying crates. A screen is placed over the drying crate to remove the vines and grass which would delay drying. The drying crates are then stacked, as shown in Figure 10.

Though pickers may harvest the berries faster on the flood than in any other way, the expense is not much, if any, less. The fields have to be arranged so as to flood small sections at a time. Water that may be needed to protect from frost later is used for this purpose, and as special crates for containing the fruit while drying must be provided, the berries have to be rehandled. In general, harvesting "on the flood" is seldom, if ever, advisable.

Figure 8 shows the lug boxes into which the berries are put when scooped and the drying crates into which they soon are emptied if picked on the flood. Figure 9 shows the construction of the drying crate and Figure 10 the filled crates stacked to dry.

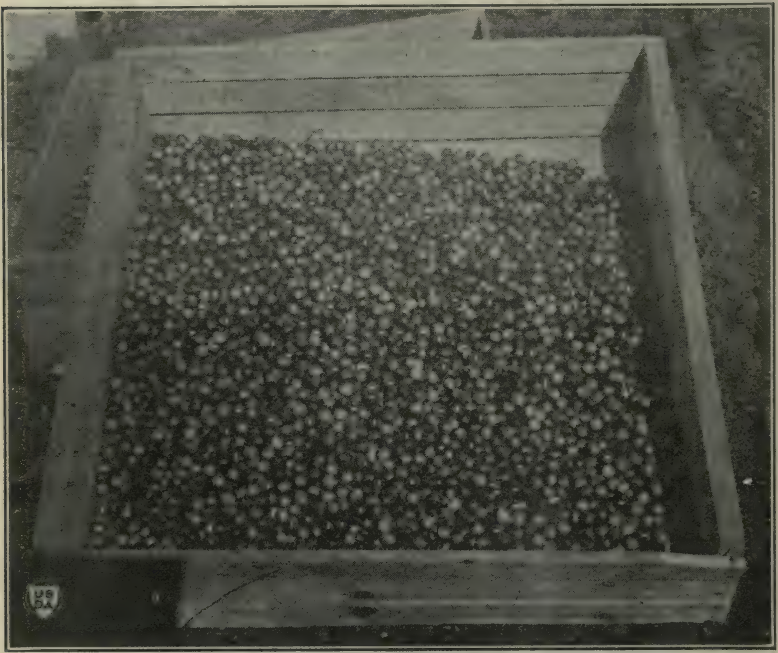

FIG. 9.—A Wisconsin drying crate for cranberries. It is 4 inches deep and 2 feet square. The sides and bottom are of lath. A crate 4 feet long is often used but is more difficult to handle.

OTHER PICKING PRACTICES.

Berries gathered from the borders of ditches usually do not keep as well as the rest and should be picked, packed, and marketed separately. It might be a good practice to devote the first day of picking to the gathering of early varieties of berries from all ditch borders. Figure 11 shows berries along a ditch being picked separately.

Often a field is lined out, as shown in Figure 12, and each picker is expected to harvest completely one strip across the field before beginning another. When the field is not lined out (fig. 6), the foreman is required to assume added responsibilty in seeing that the picking is done well.

The use of scoops or rakes tends to draw the vines regularly in the direction in which they are worked. Pickers, therefore, should be required always to scoop in the same direction year after year, because the vines can be picked over faster and cleaner and will be damaged less than if no regular plan is followed.

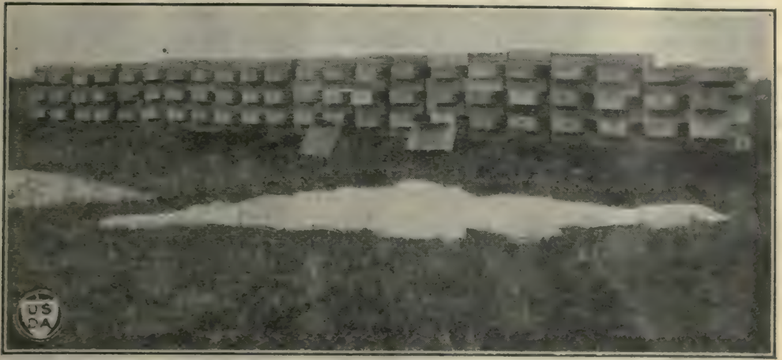

FIG. 10.—Wisconsin drying crates, stacked so that the wind blowing through them will quickly dry the cranberries scooped on the flood. This crate is longer than that shown in Figure 9. The canvas in the foreground is used to cover the stacks during rains and to keep off the dew at night.

The method of raking used in Wisconsin makes it impracticable to line out areas. The raking stroke there is 4 feet or more in width from right to left, the rake clearing the vines already harvested by the man ahead, resulting in less spilling of berries. The stroke should be toward the southeast in the central Wisconsin areas, in order to train vines in the direction of the prevailing winds from the northwest.

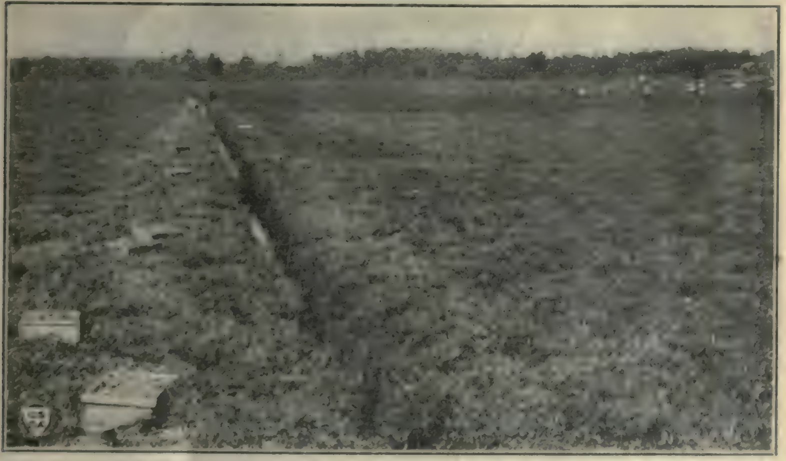

FIG. 11.—Harvesting cranberries along the ditches before the picking crew reaches that part of the field. Wareham, Mass.

Hand pickers should pick so as to pull the vines with the prevailing winds. Raking "on the flood" is started so that the rakes clear over unharvested areas, and spilled berries are then gathered by the picker taking the next strip.

TRANSFERRING BERRIES TO ROADWAYS.

A foreman, 15 scoopers, and 2 helpers make up a normal harvesting crew for a 15-acre field in Massachusetts. The helpers distribute the empty lug boxes and pile them on the upland by a road and take the filled ones from the field. Hand barrows or wheelbarrows are commonly used in carrying the full boxes from the field to the roadsides. Figure 13 shows a wheelbarrow with a bicycle wheel, which, though it lessens the injury, is too narrow to use satisfactorily on many cranberry fields. Figure 14 shows special carts made with motorcycle wheels for use on cranberry fields. Little injury is done to the vines by carts or wheelbarrows having pneumatic tires.

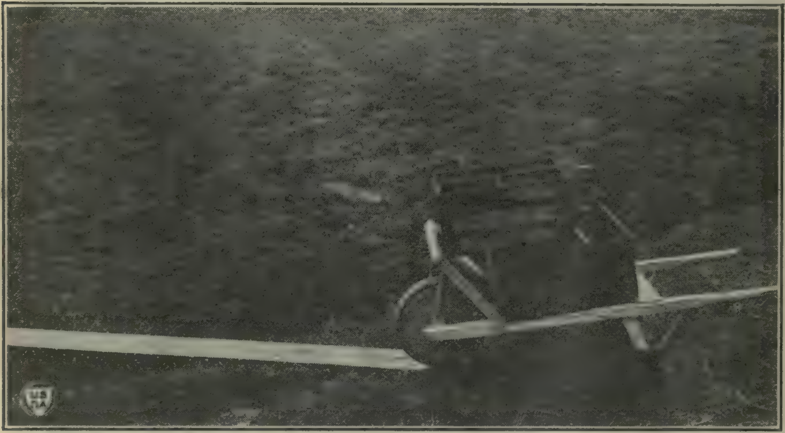

FIG. 12.—A cranberry field lined out for picking. Each picker is expected to gather the berries between two lines before starting another section. The wheel of the barrow is covered with rubber to lessen the damage to the vines. Riverhead, Long Island, N. Y.

GATHERING BERRIES LEFT BY PICKERS.

From 10 to 30 per cent of the berries are commonly left under the vines by the workers. Pickers paid by the box usually leave more than those paid by the day, though much depends on the ability of the foreman to manage them. Experienced workers leave less than those unaccustomed to picking.

After the crop is harvested the field is often flooded. Some of the berries dropped by the pickers float to the surface and are often gathered from the water. Figure 15 shows a field flooded after picking where many of the berries left by the pickers have risen to the surface and have been blown along the shore. When scooped from the water they are mixed with pieces of vines and leaves, as shown in Figure 16. They should be dried as soon as possible, either in crates where the wind can blow through them or spread on a floor. When dry they are put through separators and disposed of at once, being sold to a special trade or to some near-by preserving factory. Such fruit is not suitable for the general market, for it will not keep well. It is hard to clean and dry satisfactorily, and most growers feel that it does not pay to gather it.

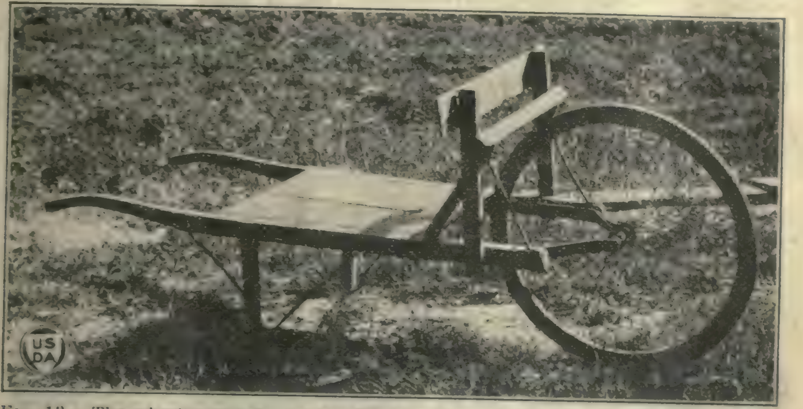

FIG. 13.—The wheelbarrow for taking filled cranberry boxes to the roads. The wheel has been replaced by one from a bicycle to lessen the injury to the vines.

YIELDS, COSTS, AND RETURNS.

The average yield of bearing cranberry fields is about 20 barrels an acre, including very many poorly kept or managed fields. The average in Massachusetts is 22 barrels, in New Jersey 17 barrels, in Wisconsin 18½ barrels, and on the Pacific coast about 20 barrels. Yields of 100 barrels an acre for a single year are sometimes secured, and even much larger yields have been reported. Very few fields, however, average over 65 barrels an acre year after year.

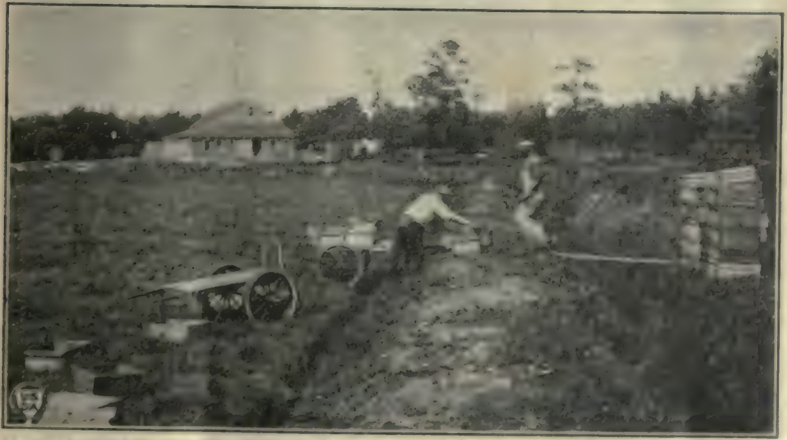

FIG. 14.—Pneumatic-tired cart for taking filled boxes of cranberries to the road. Wareham, Mass.

When a new field is to be improved it is never safe to figure on yields above the average for well-cared-for areas. Some parts of a field will prove unproductive and other parts may yield little because of insect or other troubles. Furthermore, even the best growers sometimes lose a part or even all of their crop from frost, hail, insects, or mistakes in flooding. Therefore, a yield of 35 barrels an acre may be considered an average crop for a properly located field that is well managed.

Growers should not be satisfied with an average yield of less than 30 barrels and should study their conditions carefully if they fall below that figure.

Some idea of the cost of harvesting, handling, etc., and of the gross returns is gained from the following general estimates: A cost of 70 cents per barrel should be charged for picking; for screening, storing, packing, and selling, $1.70; the barrels for packing, 70 cents each. Thus the harvesting and packing costs, on these estimates, are $3.10 per barrel. The average selling price for a series of years is about $8.71. This amount, less the harvesting costs of $3.10, gives $5.61 as the gross return per barrel to the grower, or $196.35 per acre for a 35-barrel crop, out of which he has to pay interest on the investment, taxes, and the upkeep and maintenance of the field.

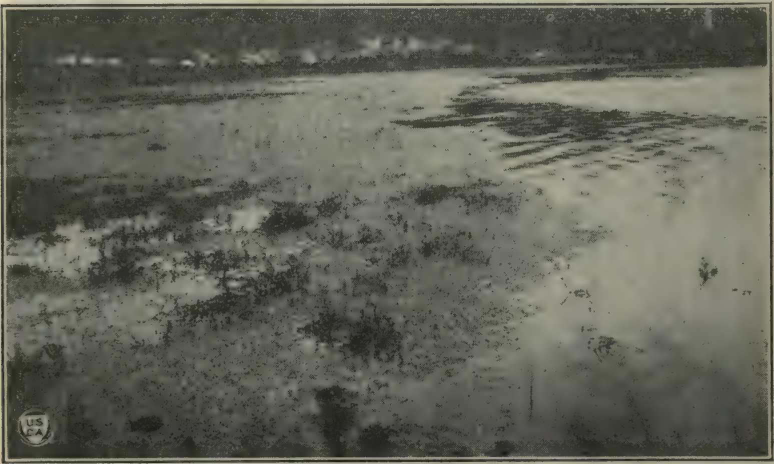

FIG. 15.—A cranberry field is often flooded after picking, to secure berries that have been dropped. Some of them rise to the surface and are driven by the wind along the shore, as shown here. They are then scooped into lug boxes, as shown in Figure 16.

HANDLING AND STORING.

EFFECT OF TEMPERATURES ON BERRIES IN HANDLING AND STORAGE.

The berries should be taken from the field to a storage house as quickly as possible after they are picked, especially if the weather is hot. As the temperature of the berries on the vines exposed to the sun is much higher than that of the surrounding air, the sooner they are cooled after picking the better they will keep. Moreover, the berries on top of boxes left in the sun after picking often scald if the air temperature reaches 80° F. or above. Table 2 shows the differences between the temperature of cranberries in crates as soon as they were picked and the temperature of the surrounding air.

TABLE 2.—*Temperature of cranberries of the Howes variety when picked at different times during the day compared with that of the surrounding air in sunny weather, taken at Wareham, Mass.,[1] October 3, 1916.*

Items of comparison.	7.30 a. m.	8.30 a. m.	9.00 a. m.	9.40 a. m.	11.00 a. m.	11.55 a. m.	2.15 p. m.	3.00 p. m.
	°F.	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*
Berries	49	62	64	75	79	81	75	73
Air	49	60	62	63	70	71	70	70
Differences	0	2	2	12	9	10	5	3

[1] Franklin, H. J. Report of the cranberry substation for 1916. Mass. Agr. Exp. Sta. Bul. 180, p. 196. 1917.

The cranberry is still a living organism after it is picked, and respiration continues, oxygen being taken in and carbon dioxid given off. The higher the temperature the faster this process goes on and the shorter the life of the berry. It has been determined[2] that on this account every rise in temperature of 18° cuts the life of cranberries in half; that is, if a bushel of cranberries is picked during the middle of a warm day when the berries have a temperature of 82° F. and the fruit is stored in a building in which this temperature is maintained it will keep only half as long as a bushel picked earlier in the day when the temperature of the berries is 64° F. and the fruit is placed promptly in a cool storehouse which maintains this temperature.

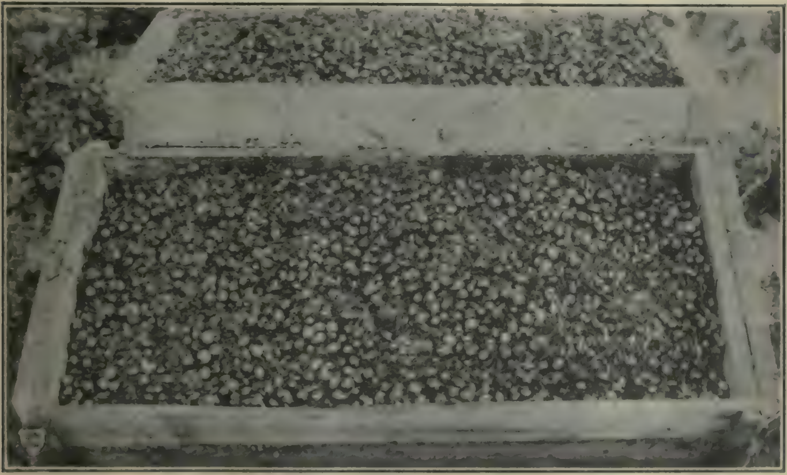

FIG. 16.—Lug boxes of cranberries scooped from the water, as shown in Figure 15. Such berries are hard to clean, do not keep well, and should be sold at once to a bakery or preserving factory.

Actually, however, berries picked and held at the higher temperature will rarely keep even half as long as those at the lower temperature, because the fungi causing decay grow faster at the higher temperature. Thus the direct effect of temperature on the life of cranberries and its indirect effect through the action of the fungi that cause decay make it doubly important that the berries be shaded in the field and cooled as soon as possible in storage.

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[2] Morse, F. W., and Jones, C. P. Studies of cranberries during storage. Chemical studies. Mass. Agr. Exp. Sta. Bul. 198, p. 81. 1920.

HAULING BERRIES FROM THE FIELD TO STORAGE.

Berries are taken from the field to storage houses by wagon, truck, boat, or car. The wagon always should have springs, to avoid bruising the berries in going over rough ground. Many now use auto trucks, and a few growers have canals and use boats to carry their berries to the storage house. Some have tracks with small cars for this purpose, as shown in Figure 17.

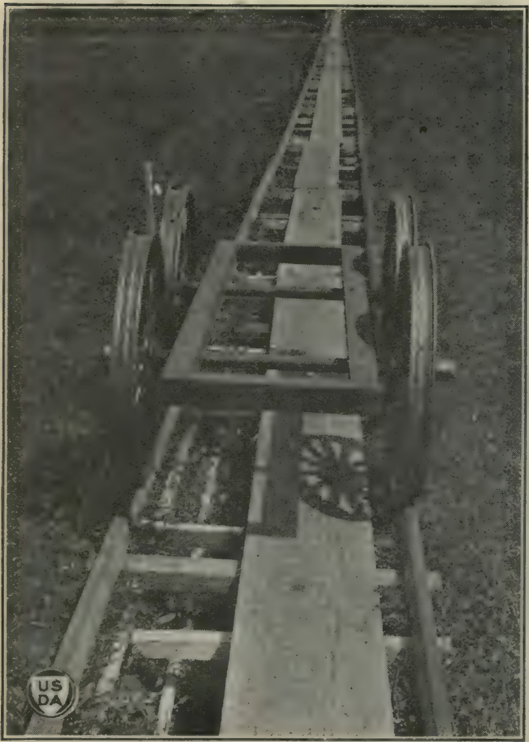

FIG. 17.—Track with car to take boxes of cranberries from the field to the storage house. Ilwaco, Wash.

STORAGE CRATES.

The lug boxes employed in the field are commonly used also as storage crates. Figures 8 and 18 show the types most common in Wisconsin, Figure 19 that used in Massachusetts and somewhat in other sections, and Figure 20 one used to some extent in New Jersey. Since the half-barrel box came into favor as a shipping container it is being used more and more as a lug and storage box (fig. 21). Its use in this way is advisable, for it saves room in the storage house, greatly reduces the labor of box repairing, and the helpers handle considerably more fruit in a day in these containers than they do in bushel lug boxes.

STORAGE HOUSES.

A storage house should be conveniently arranged for sorting and packing the berries, as well as for storing them, and so constructed that it can be readily ventilated and a relatively uniform low temperature maintained.

A very convenient storage house is one built on a hillside where the berries can be carted direct to the top floor, run through separators to the lower floor and screened there, the design varying with local conditions. It should have ample capacity for storing two-thirds of the maximum crop that may be expected, besides having storage space for the barrels used in packing and room for separating and screening. A building of one floor 40 by 80 feet should be sufficiently large to accommodate a heavy crop from a 12-acre field.

A uniform low temperature in a storage house is desirable, as cranberries, like other fruits, condense moisture on their surface when taken from a low to a high temperature. Furthermore, if warm days succeed cool nights the difference in temperature may be sufficient to cause moisture to condense. Cranberries in bulk do not dry off as readily as apples and other large fruits, because the air spaces between them are so small as to retard the circulation of air through them.

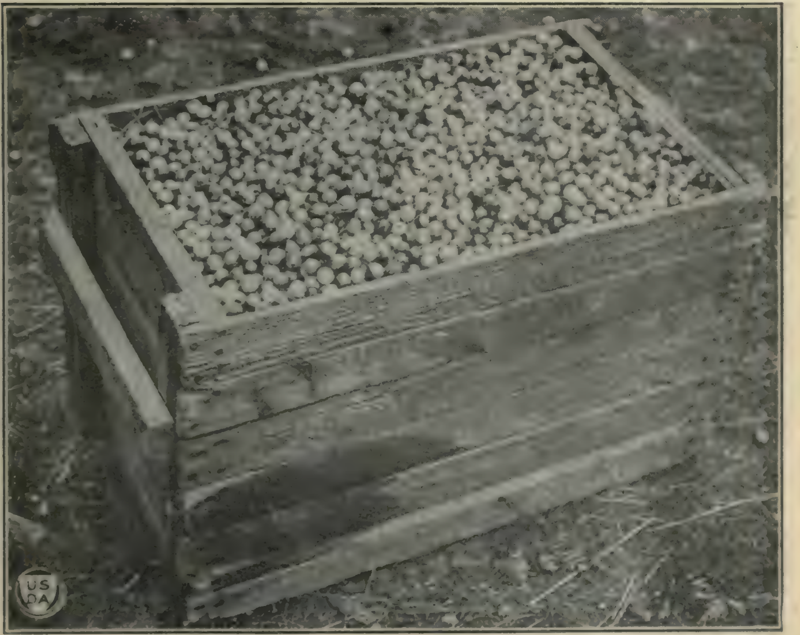

FIG. 18. A box used in Wisconsin in which to place cranberries after they are picked. It is also used as a lug box and storage crate. Size, 18½ by 11¼ by 13 inches, inside measurement.

Ventilation is needed in storage houses to allow as free a circulation of air as possible, to help dry any berries that may be slightly moist, and to lower the temperature of the fruit. Unless freezing weather makes it dangerous, the doors and windows of the building should be opened on cool nights up to the 1st of November, to cool the fruit to a temperature as near 50° F. as possible, and after that date to 40° F., if such temperatures can be maintained. In the early morning the building should be closed to maintain its cool condition as much as possible during the day. The building should be kept closed in wet weather. Some storage houses have sections of the sides which can be opened and closed, while others have windows and doors only for use in ventilating. One grower employs a large fan to force the cool night air through his storage house. By its use the temperature of the berries can be kept low (fig. 22).

The most common type of construction where uniform interior temperatures are desired is that which provides air space in the walls. This can be made even more effective if the space is filled with thoroughly tamped seaweed. Cement blocks are often used in the construction of storage houses. Unless the blocks are well hardened they may make the interior of the building damp. This may be largely avoided and the walls be better insulated by using double blocks held together by strips of galvanized iron, as shown in Figure 23. A house built of such blocks is shown in Figure 24.

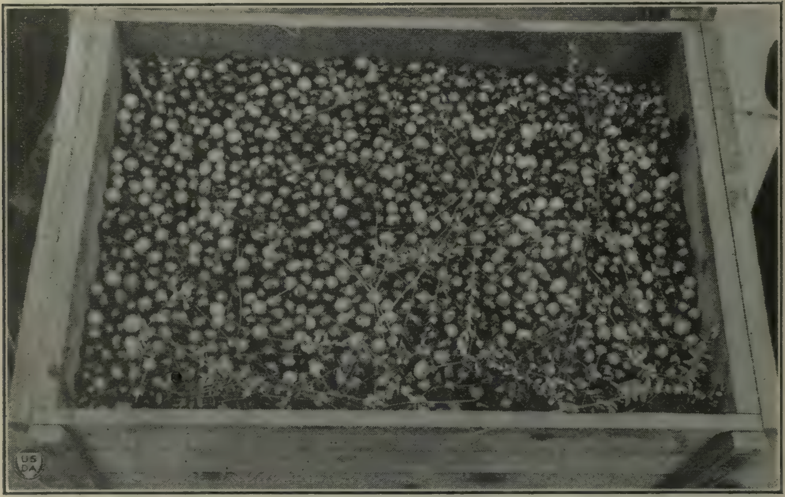

FIG. 19.—A lug box and storage crate used for cranberries in Massachusetts. This box holds about a bushel. Its usual dimensions are about 19¼ by 14½ by 8½ inches, inside measurement. See also Figure 11.

Several community storage houses have been built in recent years, and more of them may be expected in the future. Owners of small cranberry fields can not afford to build and equip a house of the best type, but several growers can combine to do this. Such central storage houses permit more uniform screening and packing than is possible where many small crops are screened and packed separately.

Except for special purposes, cranberries are rarely held in artificial cold-storage houses. This practice has not been tried out thoroughly, but it probably would not pay.

STORAGE PRACTICES.

Cranberries should never be "screened"[3] until just before they are shipped, for even with careful work some berries are injured, and the loss in berries stored after screening will be much greater than in those stored without screening.

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[3] "Screen" is a term applied to the following operations connected with the preparation of cranberries for shipment: Passing berries through a wire screen to remove pieces of vines and other trash, putting the berries through a separator, and running them over belts or tables in sorting.

The crates should be stacked so that air can circulate freely and the berries in any part of the house easily inspected and removed. Some storage houses are equipped with numerous low hand trucks on which the crates are stacked, wheeled to their position, and stored until wanted. Except for the expense of the trucks, this practice is desirable, as the labor of handling is reduced and the space under the trucks allows freer air circulation.

Many carloads of cranberries are now shipped "in the chaff" (that is, without screening), some in the regular drying crates and others loosely packed in barrels, to some of the large markets such as Chicago, New York, Boston, Philadelphia, Minneapolis, and Kansas City. These berries are chiefly for late trade and are screened to order as they are sold at these distributing centers.

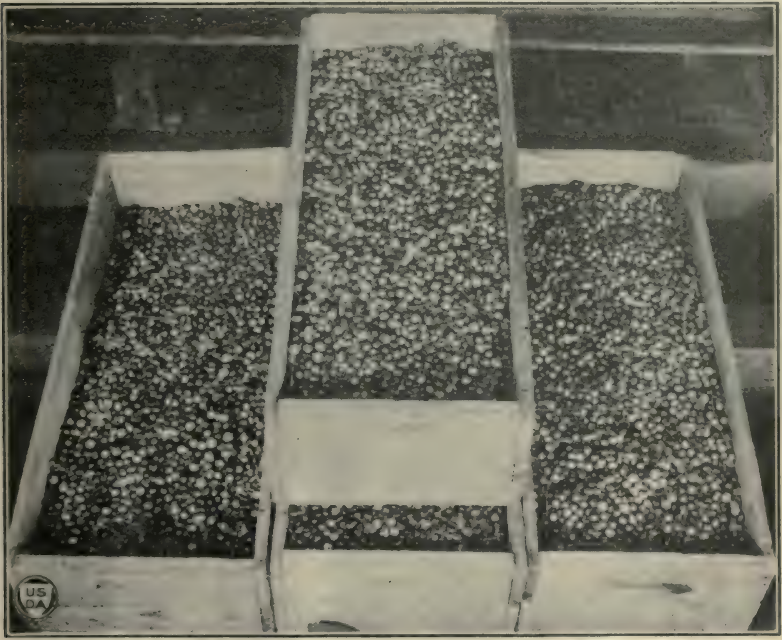

FIG. 20.—Type of lug box and storage crate used for cranberries by some New Jersey growers.

GRADING, SORTING, AND PACKING.

CLASSIFYING BERRIES AS THEY COME FROM THE FIELD.

Berries from certain fields or certain parts of the same field keep better than the rest. The best keeping berries should be stacked and kept separate while in storage and also when screened and sold.

The following field conditions usually seem to affect the keeping quality of the berries:

Long-keeping berries come from—	Poor-keeping berries come from—
Mature fields.	Young fields.
Moderately sanded areas.	Heavily sanded areas.
Areas kept dry.	Areas kept too wet.
Fields not fertilized.	Heavily fertilized fields.
Fields on which the winter flood is held late in spring.	Fields from which the winter flood is let off early.

Sometimes the crop needs no sorting, it being necessary only to clean out pieces of vines and the other chaff gathered with the berries in harvesting. This is done with a blower. The injuries incident to sorting are then avoided, and such berries can be packed and shipped safely to distant markets.

The poorer keeping berries should be sold promptly in near-by towns and cities.

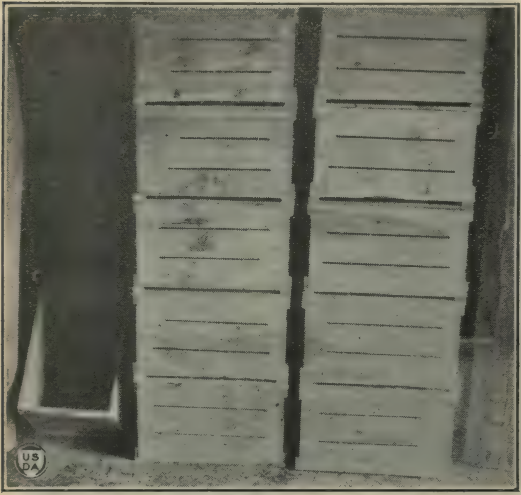

FIG. 21.—Half-barrel crates for shipping cranberries. Note the slits for ventilation. There are similar openings in the top and bottom.

GRADING AND SORTING.

Modern sorting machinery is shown in Figures 25, 26, and 27. The modern machines all do good work, if properly adjusted. The boxes of berries are emptied into the hopper at the top of the separator (fig. 25). A wire screen across the top takes out weeds and vines; a fan or blower cleans out the leaves and other rubbish; and the berries go down a series of stairs or bounding boards which separate the decayed and soft berries from the sound fruit. Sound berries bounce freely, while decaying ones do not bounce but fall into separate receptacles, shown beneath the machine. Such a machine can be run by a 1-horsepower engine. Two machines with moving screening belts require a 1½-horsepower engine.

Figure 26 shows a close view of a grading device. All small or pie berries after coming through the machine pass through the wire grader, while the larger berries pass over it.

Figure 27 shows sorters at the belt "screens." The berries coming from the separators fall onto the moving belts and are carried past the sorters, who remove any bruised, decaying, or frosted berries not taken out by the separators. Belts from several separators are often arranged to carry the berries to a main belt conveyor, which in turn takes them to the packing room.

Figure 28 shows the packing-room end of the belt at the right in Figure 27, the berries falling from the belt down a 2-way chute into barrels. With the sorters and moving belts in a separate heated room (fig. 28), the berries are exposed to a high temperature for a minute or two only, both the storage room and the packing room being cool.

Figures 29 and 30 show a different arrangement of moving belts with a separate heated sorting room. The berries all come into the sorting room on one belt, as shown at the right in Figure 29. They are distributed to the several moving belts at which the sorters sit and are carried outside into the packing room at the left. The end of one of these belts is shown in Figure 30.

With such arrangements as those shown in Figures 27 to 30, inclusive, the berries are kept in a cool storeroom while being put through separators. They pass from the separators to moving belts which carry them through the heated sorting room and out to the cool packing room, not staying in the former long enough to warm up appreciably or to condense much moisture, and when so handled the berries will keep much better than where the separating, sorting, and packing are all done in a heated room.

Stationary tables (fig. 31) are sometimes used for sorting. They are not generally as efficient as moving belts and are not to be recommended, but they can be used to advantage by those who have only a small area in cranberries not located near a community storage and sorting house with modern equipment. If they are painted white, the light they reflect will make it easier to sort out poor berries. The walls of the sorting room should be whitewashed to aid the sorters in their work by furnishing the maximum of light.

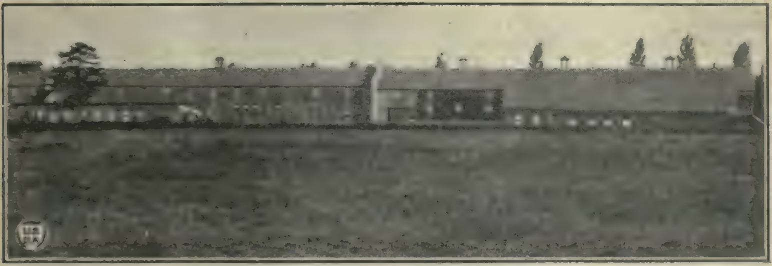

FIG. 22.—Cranberry storage and screen house. Note the fire division wall in the center and the cranberry field in the foreground. This house has a large power fan, which is used to force the cool night air through the storage rooms; heavily insulated doors aid in maintaining a uniformly low temperature. Whitesbog, N. J.

The only grading commonly done except in Wisconsin is the removal of the very small berries, thirteen thirty-seconds of an inch or less in diameter. Figure 26 shows a device for this purpose. The small berries, commonly called " pie berries," do not keep as well as the rest and are usually sold to bakeries or preserving factories.

In Wisconsin many growers use a separator to which is attached a sizer that separates into five sizes. Berries so graded are very attractive by reason of their uniformity. Because the combined separator and sizing machine needs much more constant attention and adjustment than the machines used in other sections it is gradually being replaced by them.

PACKAGES AND PACKING.

The packages most used for shipping cranberries are the cranberry barrel (fig. 28) and the half-barrel crate (fig. 32). The barrel holds about 85 quarts and when full varies in weight from 90 to 105 pounds, according to the variety and texture of the berries. Two half-barrel crates cost somewhat more than one barrel, but the berries keep much better in them because of the ventilation and the reduced mass bruising. Another package used to some extent, but less desirable than the barrel or half barrel, is that shown in Figure 32.

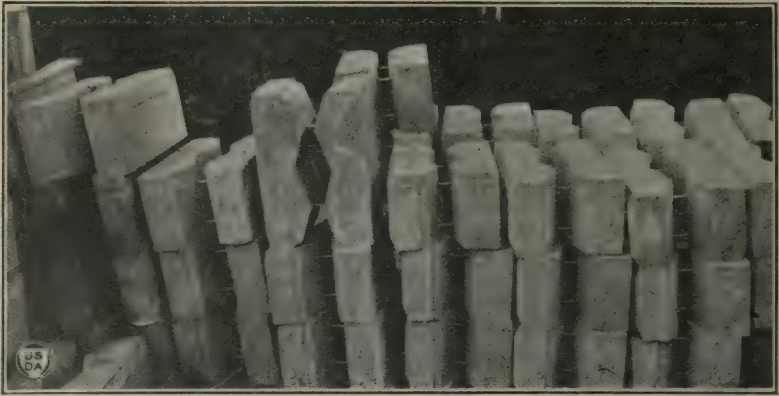

FIG. 23.—Double cement blocks, the two parts being connected by four galvanized staples or rods one-fourth inch in diameter, thus leaving an air space in a wall made of them. The temperature of the interior of a building with such walls is less variable than one constructed of either solid or hollow cement blocks because of better insulation provided by this type of block.

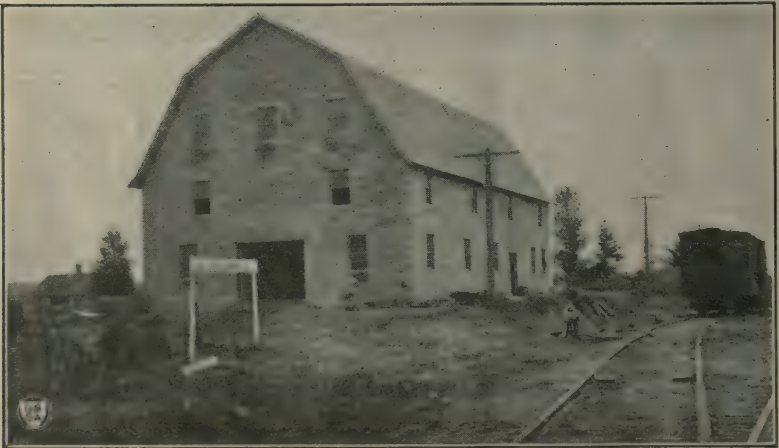

FIG. 24.—Cement-block storage and screen house for cranberries. This has an entrance on the first floor so that an auto truck can be driven into the storage room. An elevator carries the boxes of berries to the barrel storage room on the third floor where they can be emptied into hoppers. The separating and sorting are done on the second floor. Below the first floor is a basement room for winter storage. Beaver Brook, Wis.

In packing, the berries fall from the moving belts into the shipping containers. A good automatic device to keep the berries from being bruised by the drop into the barrel is shown in Figure 33.

When the barrel is empty, as shown in the illustration, the berries roll down the inside. As it fills, the weight of the berries acts against a counterweight and gradually brings the barrel into an upright position. The berries should be shaken down and well pressed when packed, so that they may not be slack on arrival in distant markets.

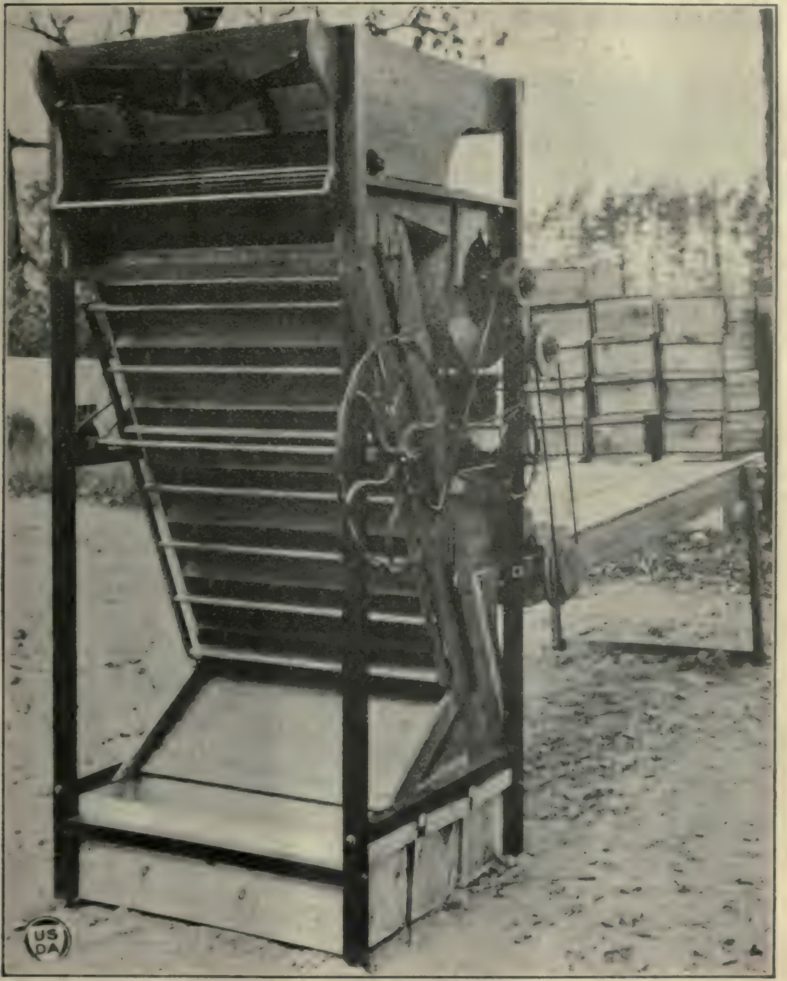

Fig. 25.—A modern cranberry separator for grading and sorting. Unsorted berries are poured into the hopper at the top. The berries first fall through a wire screen, which removes all pieces of vines. They are then fed through a blower, which takes out all the leaves and other chaff. They next fall down a series of steps, and the decaying and frosted berries are separated. The good berries pass over a wire grader and to moving belts for hand sorting and finally pass into shipping packages at the farther end of the belts. Because sound berries are much more resilient than soft ones, the steps of this machine are arranged to separate the berries according to their rebound.

Besides the common apple-barrel headers, frequently used in heading cranberry barrels, several special makes have been designed by growers. Two of these are shown in Figures 30 and 34.

BRANDS.

Before the packages are closed the size and brand of the berries should be determined. Most high-grade cranberries are now marketed under a brand and should be dry, sound, reasonably uniform in color and size, free from frosted and wormy berries, vines, and other rubbish, and firmly packed. Inferior berries should never be packed under a brand. Buyers will pay more for berries sold under a dependable brand than for unbranded fruit.

Growers' selling associations have adopted brands for fruit shipped by them and have stated the requirements of each brand. For example, in Massachusetts nearly 90 per cent of the crop consists of the Early Black and Howes varieties. The New England Cranberry Sales Co. has six brands for the Early Black and five for Howes. The requirements for each of these brands, as given below, are posted in the packing houses of the growers belonging to the association.

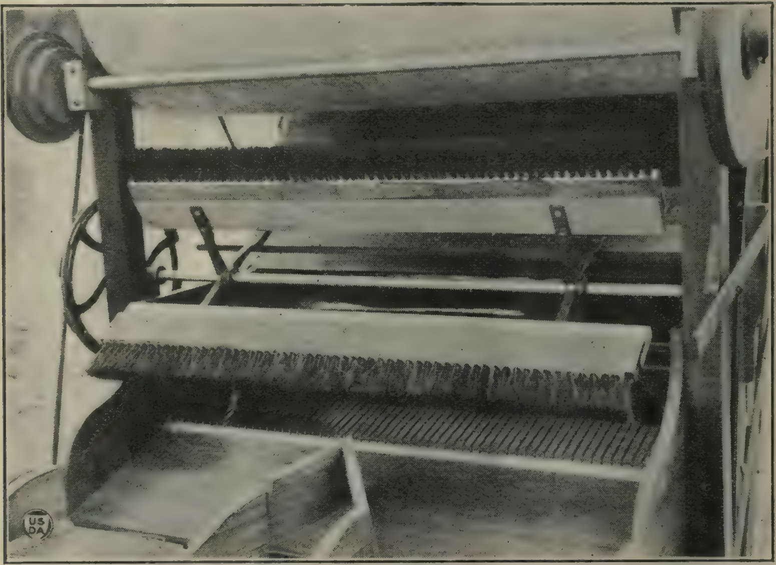

FIG. 26.—A grading device for cranberries. After being sorted by passing through the machine shown in Figure 25 the berries run over the wire grader under the lower brush. The small or "pie" berries fall between the wires. The revolving brushes keep the wires from clogging.

Requirements of the New England Cranberry Sales Co., for brands of the Early Black and Howes varieties.

EARLY BLACK.

Skipper.—Early Blacks; averaging 75 per cent colored, with not over 10 per cent of white berries; counting not over 140 to the cup,[4] fit for 15 days' travel, i. e. of a quality to pass inspection after being 15 days in transit to market.

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[4] The cup is a standard half-pint measuring cup. In making a count it is filled without heaping, gently shaken, and the berries counted.

Chanticleer.—Well-colored Blacks; count from 130 to 150; fit for 15 days' travel.

Mayflower and Monarch.—Blacks; at least 90 per cent colored; count less than 130; fit for 15 days' travel.

Minot's Light.—Fully colored Blacks; count less than 130; fit for 7 days' travel.

Harvard.—Blacks of uniform dark color; count less than 100; fit for 7 days' travel.

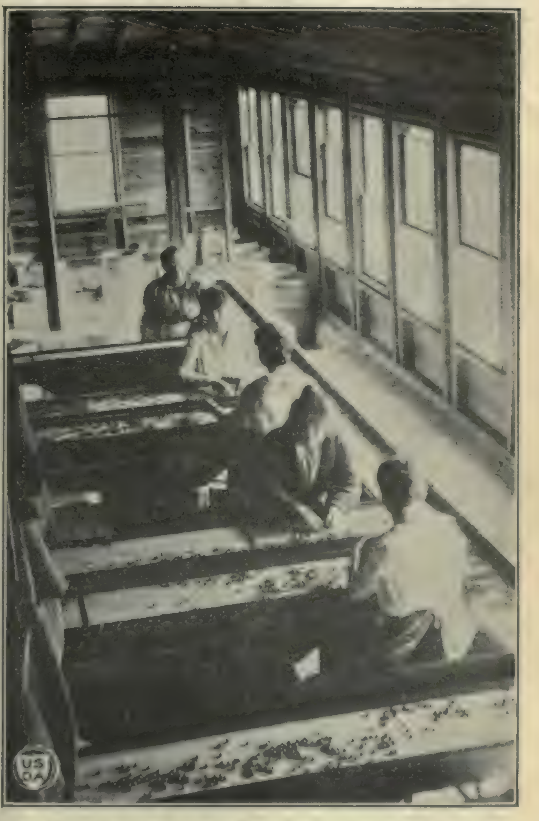

FIG. 27.—Hand sorting cranberries. Sorters sit at moving belts, which carry the berries from the separators (at the left) to the main moving belt (shown at the right of the women), by which they are carried to the far end for packing. Note the abundant light from the windows at the right. Wareham, Mass.

Capitol.—Blacks of uniform red color; count not over 140; fit for 15 days' travel.

HOWES.

Turkey.—Howes; at least 75 per cent colored; not over 5 per cent white berries; count not over 120; fit for 20 days' travel.

Battleship.—Howes; at least 80 per cent colored; count from 120 to 140; fit for 20 days' travel.

Honker and Mistletoe.—Howes; at least 80 per cent colored; count less than 120; fit for 20 days' travel.

Holiday.—Howes of uniform deep-red color; count less than 120; fit for 15 days' travel.

Santa Claus.—Howes of uniform deep-red color; count not over 95; fit for 15 days' travel.

Other varieties in Massachusetts and other sections are shipped under brands the requirements of which are designated in a similar manner. Inspectors hired by the association visit the packing houses and determine the brand under which the fruit in each instance is to be shipped. If a grower questions the findings of the inspector, a committee appointed by the association decides the matter.

MARKETING.

TIME OF SHIPPING.

The first shipments in Massachusetts and New Jersey usually are made within a week after picking begins, in early September, and 90 per cent of the crop is shipped and sold by the first of December.

Few Wisconsin shipments are made until about October 1. After the middle of November in Wisconsin there is danger of such low temperatures that the berries will be injured in the storage houses, while being hauled to the shipping station, or in transit. The whole crop, therefore, must be shipped in a period of about six weeks.

Late shipments usually bring the highest prices, but delayed shipping means some loss from decay, natural shrinkage, and increased cost of screening and packing. Most growers prefer to dispose of their berries as promptly as possible. The loss from natural shrinkage, due mostly to the giving off of moisture, varies from year to year and with the climate and conditions of storage, sometimes amounting to 12 per cent in three months of storage. It is greatest in the first part of the storage season. The loss from decay varies greatly but is seldom less than 4 per cent a month and is greatest in the warmer part of the fall. From his experience with the keeping quality of his fruit each grower must determine when his fruit should be shipped.

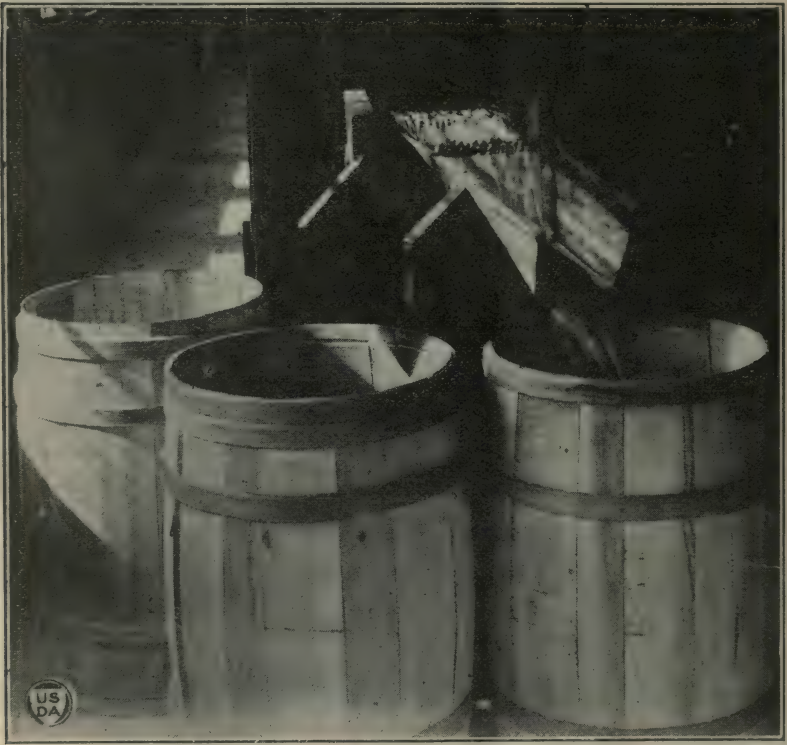

FIG. 28.—The end of a moving belt in a cranberry packing room. Here a partition separates the packing room from the sorting room. Note also the gate used to close either of the chutes as soon as the barrel is filled. Wareham, Mass.

WEATHER CONDITIONS AND MARKETING.

The relation of weather conditions to marketing should be considered by all shippers of cranberries. In general, cool weather stimulates the demand for this fruit, while warm weather lessens it.

Warm weather during harvesting hastens the ripening of the cranberry in the field and tends to impair its keeping quality. Moreover, berries shipped during warm periods will not hold up well in transit and in city markets. With cool weather during harvesting ripening is delayed, decay is much less rapid than during warm weather, and the cranberries hold up well in transit and in markets.

In very cool weather there is danger that the berries may freeze in transit unless the containers are covered with thick paper or otherwise protected.

DISTRIBUTION.

The individual grower as a rule can not readily secure the information necessary to market his fruit to the best advantage. His attention is absorbed in his problems as a grower. Besides, a good grower is not necessarily a good salesman. Many excellent crops of fruit are sold at a disadvantage for this reason.

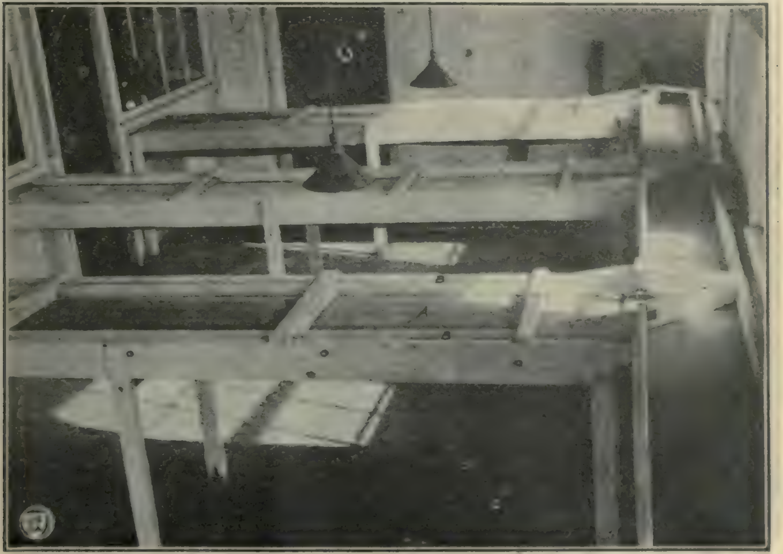

FIG. 29.—Cranberry sorting room. The berries come from the separator into this room on the moving belt at the right. They are switched to the belts running across the room and at which the sorters sit. Note the three spaces on each sorting belt, the broad center one (*A*) for the good berries and the narrow ones (*B*) at the sides in which the poor berries are placed. Hammonton, N. J.

A properly manned selling organization insures the handling of the crop by those who are thoroughly trained in selling, transportation, and all other features of merchandising.

The same information regarding market conditions, shipments en route, and other matters having to do with price returns as would be needed by an individual shipper working independently serves equally well for all the growers who are represented in a cooperative selling organization.

Both grower and consumer are benefited by the widest possible systematic distribution of the crop. Such a distribution tends to stabilize the industry, assuring to the grower a steady demand for his cranberries. A strong organization of growers can effect a wide distribution of the crop in a degree not possible with each grower acting independently and can increase the demand for its product by well-planned advertising.

In enabling a cooperative sales company to succeed, each grower must see that every barrel of cranberries prepared for market is up to the standard for which it is labeled. Each member must pack not merely to pass inspection, but in the best possible manner. Cranberry growers have found such cooperation necessary and have formed several cooperative organizations.

COOPERATIVE ORGANIZATIONS.

In Wisconsin the earliest movement toward cooperative selling seems to have begun in 1897. It was started by some of the leading cranberry growers of central Wisconsin, who first banded themselves into the Cranberry Growers' Union, with headquarters at Grand Rapids (now Wisconsin Rapids), Wis., but no real success was attained until the formation of the Wisconsin Cranberry Sales Co. in 1905, with an established sales manager, located first at Des Moines, Iowa, and later at Chicago.

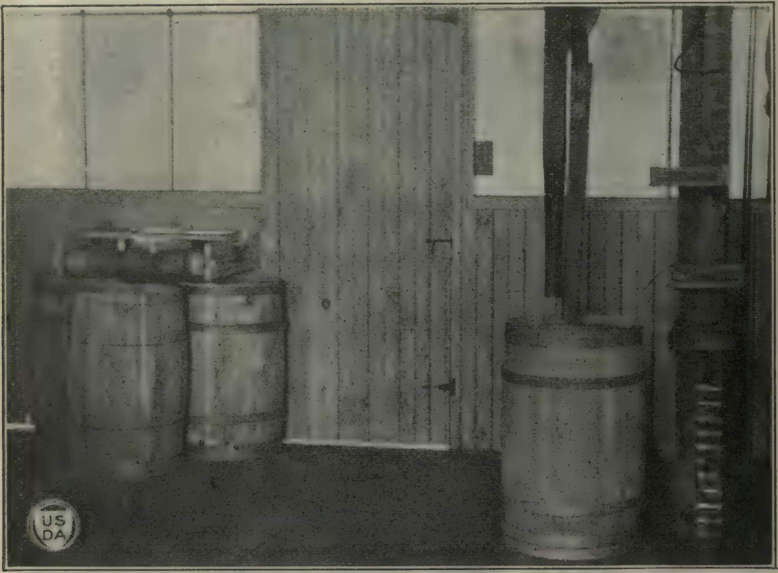

FIG. 30.—Cranberry packing room. Above the three barrels the end of one of the moving belts shown in Figure 29 can be seen. The center barrel receives the good berries which are carried by the belt *A* in Figure 29; the poorer berries carried by belts *B*, *B* (fig. 29) drop into the side barrels. At the right is a barrel header. Hammonton, N. J.

The success of growers in Wisconsin in cooperative selling was soon realized, and in 1907 the New England Cranberry Sales Co. and the New Jersey Cranberry Sales Co. were formed, joining the Wisconsin Cranberry Sales Co. in the National Fruit Exchange, with headquarters in New York and a branch office in Chicago.

In 1911 the Growers' Cranberry Co., a New Jersey cranberry-selling corporation organized in 1895, joined with the National Fruit Exchange to form the American Cranberry Exchange, which is now a membership corporation organized under the laws of the State of Delaware and a cooperative nonprofit-making organization.

The American Cranberry Exchange is the most important of the cooperative organizations, having member units in each of the three leading cranberry-growing regions—in Massachusetts, the New England Cranberry Sales Co.; in New Jersey, the Growers' Cranberry Co.; and in Wisconsin, the Wisconsin Cranberry Sales Co. It handles the entire crop of the members of these three organizations and in 1922 handled about 66 per cent of the total crop. It reports market conditions to the growers, suggests times for shipment, sells the fruit, makes collections, and maintains vigorous and effective advertising.

The three sales companies establish the brands of cranberries, build and operate community storage and screen houses, establish systems and periods of pooling, and pay the growers for their crops.

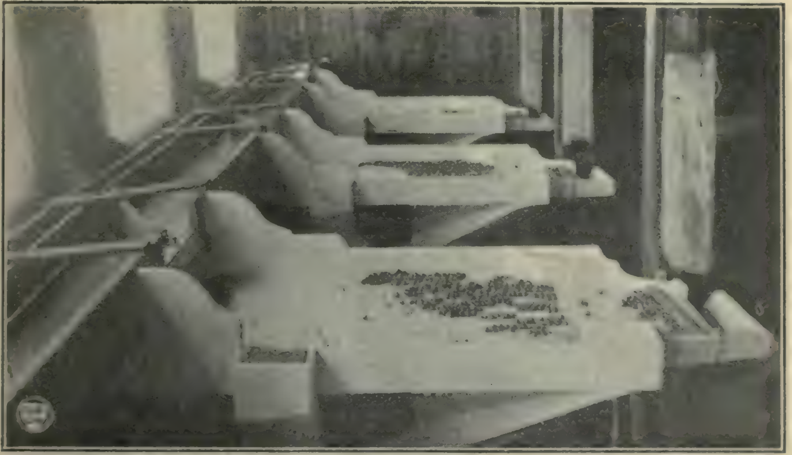

Fig. 31.—Cranberry sorting tables. Cranberries are often sorted on stationary tables, one type of which is shown here. Sorters can pick out defective berries more easily on white tables than on dark ones. Stationary tables are generally less efficient than moving belts. Whitesbog, N. J.

On the Pacific coast the growers organized the Pacific Cranberry Exchange in 1917, which operates in a manner similar to that of the American Cranberry Exchange.

In Massachusetts there is a second cooperative organization, the Cape Cod Cranberry Distributors. This differs from the American Cranberry Exchange chiefly in that only cranberries from Massachusetts are handled and that its returns to a grower are based on the sale of his crop instead of the fruit being pooled.

In each eastern section a portion of the crop, about 25 per cent, is handled through agents, shipped to commission men, or disposed of in other ways.

The following discussion of the American Cranberry Exchange is included to give growers information about the working methods of an efficient cooperative cranberry-marketing organization.

CROP ESTIMATES.

Full information regarding the quantity and quality of the crop is essential to the proper marketing of cranberries. Such information must be available by the 1st of September as a basis for fixing a fair opening price. Careful estimates of the effects of frost during the harvesting season are also necessary. The American Cranberry Exchange, through the sales companies, is well situated to secure this information, because a large percentage of the growers are members. Reports of crop prospects are made by all members at the beginning of the harvest season and from time to time later, so that, in addition to Government crop reports and other information available to everyone, this organization has its own estimates.

MARKET REPORTS.

Members of the sales companies are kept in constant touch with market conditions and future prospects, which not only informs the growers but promotes confidence and the spirit of cooperation.

INSPECTION AND BRANDS.

The sales companies have established grades for each variety they ship, having in all 82 different brands, thus enabling the buyers, without seeing the fruit, to order the variety, size, color, and quality of cranberries they want. In addition to relying on the cooperation of its members, the New England Cranberry Sales Co. has a system of inspection, to insure that the character and uniformity of pack accord with the standards of its brands.

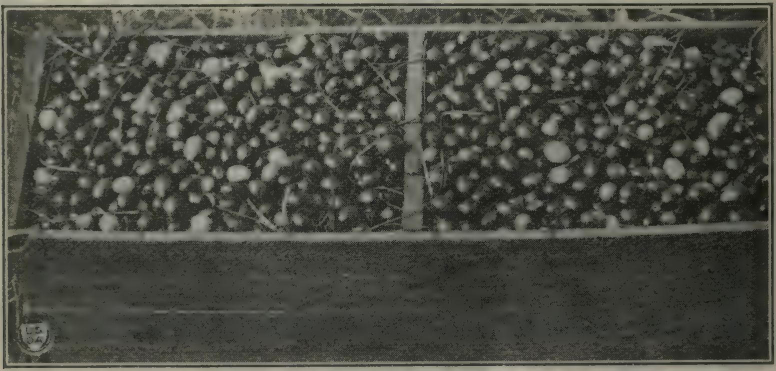

FIG. 32.—A crate of Champion cranberries. This type of crate is used in New Jersey somewhat as a picking or lug box and by a few growers as a shipping package. It holds 28 quarts.

COMMUNITY, STORAGE, AND SCREEN HOUSES.

Several community storage and screen houses have been built by the New England Cranberry Sales Co. Berries brought to these houses are handled uniformly and in the best possible way, the cost of sorting and packing thus being lowered somewhat and the number of undesirable and unprofitable shipments reduced.

TIMING SHIPMENTS.

To effect proper distribution, all markets in the United States and Canada should be supplied with cranberries from early September until after New Year's Day, and no market ever should be oversupplied. To accomplish this, an organization loyally supported by its members, with full information regarding market conditions, is necessary. As far as conditions allow them to do so, the members must follow the instruction of the sales manager in timing their shipments.

In September large shipments of the best fruit are made to the jobbers and retailers for stocking up. Much smaller shipments go forward in October, as it is sufficient then merely to maintain the stock in trade. Heavy shipments are needed in November and December to meet the holiday demand, and after New Year's Day only a very small percentage of the crop remains in the hands of the growers.

A FAIR OPENING PRICE.

A fair opening price must be established when the first shipments are made, or soon after. A fair price is one that will give the largest return to the grower compatible with ready distribution and free consumption. The opening price should be so fixed that the demand for cranberries will steadily advance this price throughout the selling season, to such an extent as to compensate the grower for his risk in holding his fruit, interest on investment, storage shrinkage, and the increase in the cost of sorting. It is estimated that the average storage shrinkage under present conditions up to February is from 30 to 40 per cent. A fair price for berries held into the winter, therefore, must be much higher than for those sold in early fall.

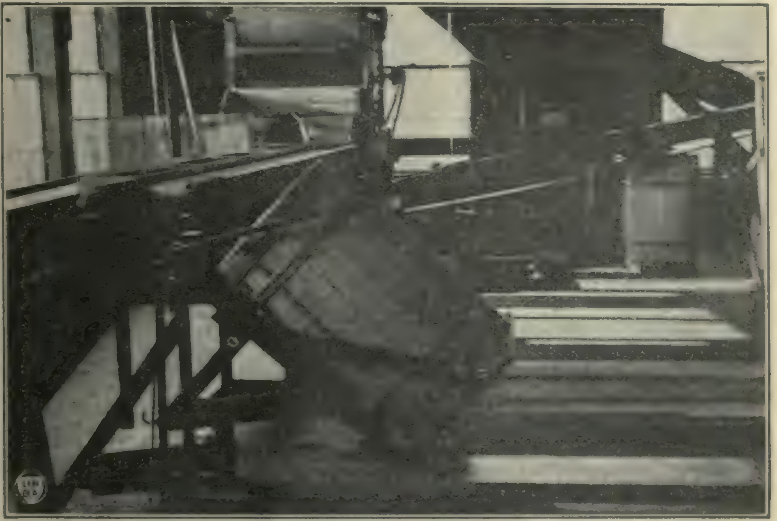

FIG. 33.—Automatic device to lessen the injury to cranberries caused by their drop into the barrel. As the barrel fills, the weight of the berries, increasing gradually and working against the concrete counterweight (seen at the left near the floor) brings it to an erect position. Plymouth, Mass.

If an association establishes a fair opening price for several years and buyers come to have confidence in that price, it will be easier to sell the crop, a much better distribution will be effected, and growers will receive a better price for their products than if no such association existed.

AVERAGING SYSTEM OF PAYMENTS.

The cranberry sales companies sell their berries in pools and pay for all the fruit in each pool, rejections excepted, at the same rate.

Some such system of payment seems necessary, for the sales manager must be free to ship berries to any place in order to keep all markets supplied with the grade of fruit they require.

When a shipment is rejected or brings a low price because of poor quality, a committee of the sales company determines whether the fault was with the grower or whether the inferior condition of the berries resulted from the treatment received after leaving his hands.

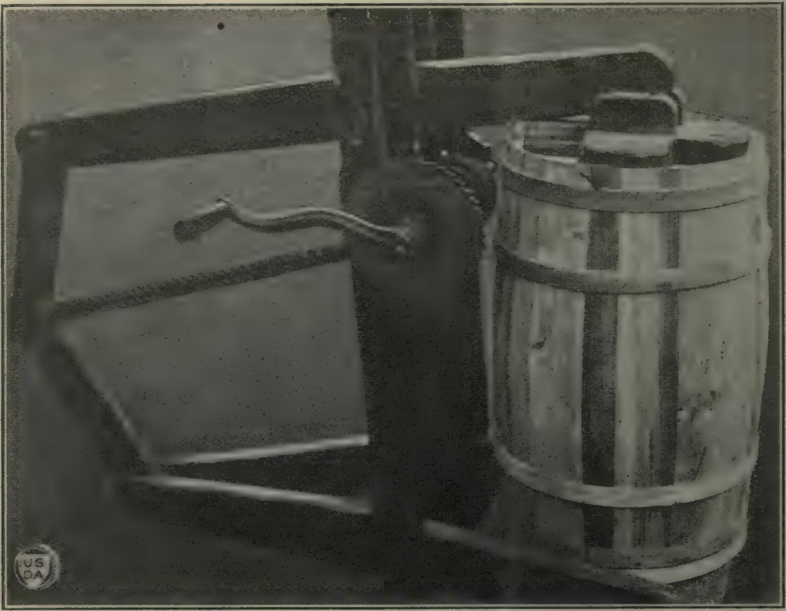

FIG. 34.—Cranberry barrel header used to some extent in Wisconsin.

If the grower is found solely at fault he is paid according to what the fruit sold for. All berries not branded are classed as separate shipments and are paid for according to the actual returns from their sale.

This system has been in successful operation for several years and is generally considered satisfactory.

ADVANCING MONEY.

A member of a sales company, before his cranberries are sold, must pay for his containers and for picking, carting, sorting, and packing his fruit. He is therefore often in need of money to meet these expenses. The cooperative growers' associations arrange, when necessary, for advances on the crops.

MAKING COLLECTIONS.

The exchange can keep informed regarding the reliability of those with whom it deals and can make collections much more easily than individual growers, thus preventing many losses.

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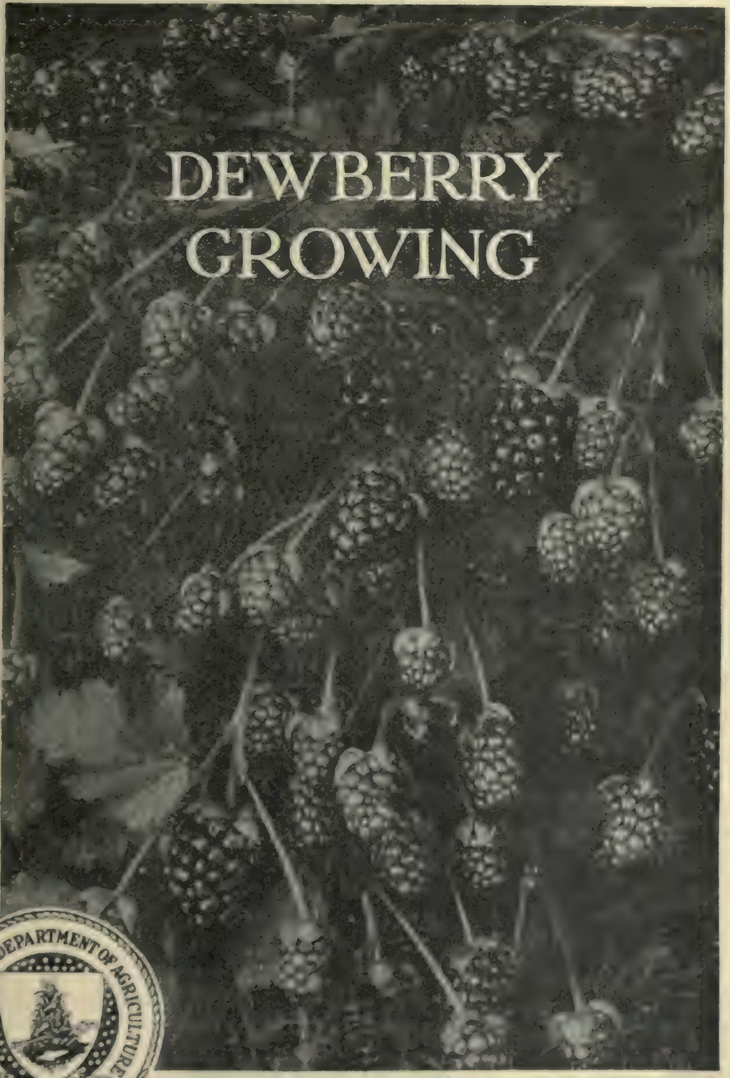
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1403

DEWBERRY GROWING



THE DEWBERRY, called also trailing blackberry, is extensively grown in a small number of localities in North Carolina, Michigan, New York, and New Jersey where, because of the skill of the growers in using special methods of training and culture, it is very profitable.

This bulletin points out certain of these operations which have been found essential. In the North Carolina dewberry section the operations of greatest importance seem to be (1) the removal of all canes, old and new, as soon as the crop is picked; (2) the application of large quantities of fertilizer in early spring and again in midsummer immediately after the canes have been cut out; and (3) the training of the canes to tall stakes.

In the Michigan section the covering of the basal portion of the canes in late fall to prevent winter injury is considered of primary importance. In the New York section protection from winter injury by allowing weeds to grow and cover the canes is considered important.

Cultivation and harvesting are discussed, and carriers which materially reduce picking costs are illustrated.

This bulletin is a revision of and supersedes Farmers' Bulletin 728, Dewberry Culture.

Washington, D. C. Issued June, 1924

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DEWBERRY GROWING.

By George M. Darrow, *Pomologist, Office of Horticultural Investigations, Bureau of Plant Industry.*

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THE DEWBERRY is closely related to the blackberry, having a root that lives for many years and a top that lives only two years. Like the blackberry, it bears fruit upon last year's canes, which die soon after they have fruited. It is distinguished from the blackberry in having canes that trail on the ground, while those of most blackberries are upright. From this habit it receives the name "trailing blackberry," which is commonly applied to it. In the wild state the canes of the dewberry form new plants by rooting at the tips, while blackberries propagate themselves chiefly by suckers. Further, the dewberry fruit clusters are small and open, while the blackberry clusters are usually rather dense. (See fig. 1.)

The fruit of the dewberry is similar to that of the blackberry, but because dewberries ripen earlier than most true blackberries their culture has proved profitable in many sections. Because the canes of the dewberry trail on the ground instead of growing erect, as do those of true blackberries, the methods of raising these fruits are very different. Blackberry culture is discussed in another bulletin.[1]

Recent investigations indicate that all the principal varieties of dewberries are, in reality, hybrids between blackberries and dewberries. In the wild, many hybrids of blackberries and dewberries are to be found, some with trailing canes and some with arched canes but nearly all rooting at the tips. In Europe no distinct line of separation is made between blackberries and dewberries. Varieties of blackberries introduced from that country are all semierect and root at the tips of the canes. Thus, the Himalaya and Evergreen varieties behave in this manner, as does also the Logan blackberry[2] of the Pacific coast regions of the United States.

HISTORY OF THE DEWBERRY.

The cultivated dewberry is a native of America, and all varieties are of American origin. The Lucretia was the first to be introduced into general cultivation. It was found in West Virginia soon after the Civil War and brought to general notice about 1886. Since then many other varieties have been introduced, and at present about 25 are under cultivation, none of which is as popular as the Lucretia.

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[1] Farmers' Bulletin 1399, Blackberry Growing.

[2] See Farmers' Bulletin 998, Culture of the Logan Blackberry and Related Varieties.

The four States in which the dewberry is grown extensively on a commercial scale are North Carolina, Michigan, New York, and New Jersey. The centers of the industry in those States are Cameron, N. C., Benton Harbor, Mich., Germantown, N. Y., and Hammonton, N. J. Dewberries are also grown in California, Georgia, South Carolina, Maryland, Texas, Missouri, Colorado, and to a limited extent in most of the others States. The Lucretia variety, although the one chiefly grown, is not very hardy, and for this reason its culture has been confined in the past to the milder climates. Recently it has been grown more in the Northern States and in Colorado and is proving profitable in favorable locations or when protected from severe winter conditions.

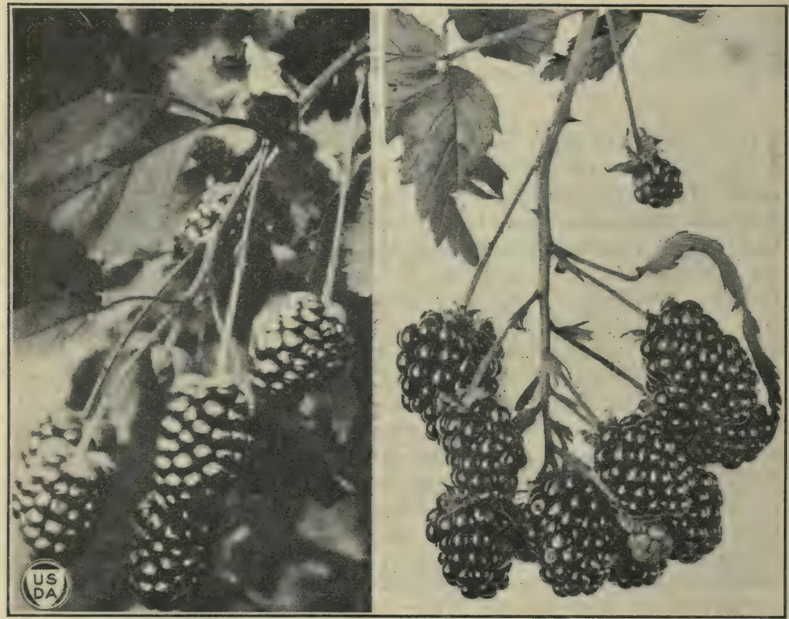

FIG. 1.—A fruit cluster of the Lucretia dewberry (on the left) and of the Mersereau blackberry (on the right). Note the small cluster of the dewberry, with its long berry stems, as compared with the larger and denser cluster of the blackberry.

SITE AND LOCATION OF A PLANTATION.

In regions where winter conditions are severe, the site for a dewberry plantation should be as well protected as possible from cold and from winds. In order to provide good air drainage, a site elevated above the surrounding country is preferred. However, it should not be exposed to drying winds or to other trying conditions.

Long hauls by wagons and motor trucks and jolting over rough roads will bruise the berries so they will not hold up well on the market. Therefore, the plantation should be as near local markets or a shipping station as possible.

SOILS.

In the wild state dewberries are found in open fields and pastures and by roadsides, especially where the soil is poor and the growth of grass and herbage is thin. In such locations its leaves can get more sunlight than where the soil is rich and the grass rank. The cultivated dewberry is grown on many types of soil. Though the plants will grow on poor land, it is necessary in order to produce good crops of fruit that it be fertile or that plant food be supplied. In North Carolina the soil in many of the large dewberry fields is a coarse sand. Fertilizers are applied liberally to plantations on such soils. In other sections clay loams and other soils are used for dewberry fields, and if they are fertile less plant food need be added. As the dewberry has a very deep root, it is able to get moisture from a considerable depth and is, therefore, not as subject to drought as raspberries and blackberries.

Dewberries should not be set on wet soil. Because of their deep rooting system they are more susceptible than many other fruits to injury by wet soils. In some sections root-rot has been found to kill plants where the soil was only slightly wet; on the other hand, the soil must furnish a sufficient moisture supply, especially at the time the berries are developing and ripening. Coarse sandy loams with a clay subsoil are the leading soil types in three of the principal dewberry sections. Any fertile soil provided with good drainage and yet with a good supply of humus to retain moisture is suitable for growing dewberries.

PREPARATION OF THE SOIL.

As the dewberry plants are to occupy the soil for several years the land should be very thoroughly fitted before they are set out. If the soil lacks humus, the use of cover crops before planting dewberries will be helpful. Much better results will follow if the land is planted to cultivated crops for two years prior to setting it to dewberries. The plants will grow better the first year, and a crop will be borne earlier than without such preparation. Often very little fruit is obtained the year after planting, yet Figure 2 shows a plantation set the previous year which was yielding a good crop. This field had been carefully prepared before the plants were set.

PLANTING.

Dewberry plants are usually set during the winter and early spring in the South and in early spring in the North. As the tips of the canes which root in the fall continue to develop until very late, more mature plants will be obtained in the spring. For this reason fall planting is not practiced. Figure 3 shows strong Lucretia dewberry plants ready to be set. Because the essential factor of success in planting dewberries is a moist soil, they should be set as early in the spring as possible, for there is usually more moisture in the ground then than later and a larger percentage of the plants will live.

The plants should be set as soon as possible after being received from a nursery or after being dug. Exposure of the roots to the air dries and weakens them. When planting, the soil should be thoroughly packed about the roots. Thorough packing brings the soil moisture in contact with the roots and prevents the air from drying them.

The hill system of training, as shown in Figure 2, is commonly used in North Carolina, and the plants are usually set 5 feet apart each way. If the canes are to be trained in solid rows the plants are usually set in New Jersey 3 feet apart in rows which are 4 to 6 feet apart and in Michigan 2½ feet apart in rows 7 feet apart. In the Germantown section of New York they are set 2 feet by 7 to 8 feet apart. Figure 4 shows a field planted 3 by 6 feet in which the canes are to be trained to stakes. Figure 5 shows a field in which the canes are trained to a low trellis.

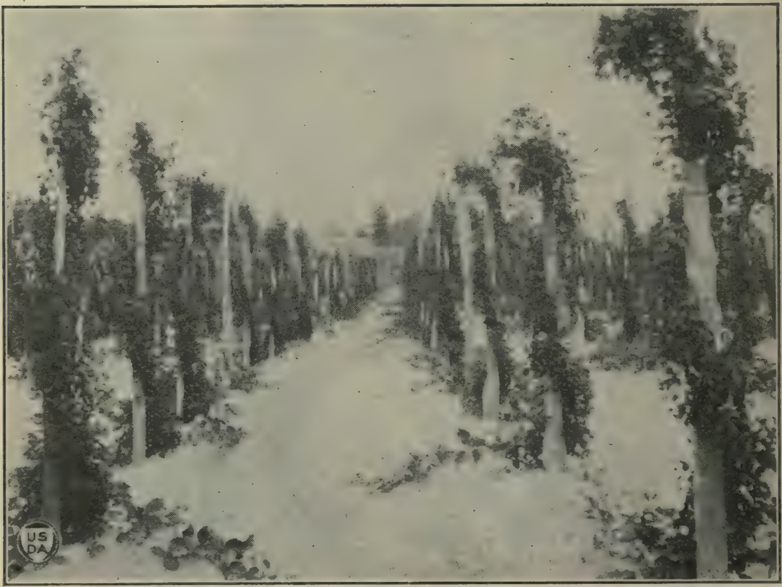

FIG. 2.—A field of Lucretia dewberries in North Carolina bearing a good crop the year after planting. Photographed June 12.

INTERCROPS.

During the first season, vegetable intercrops that require frequent cultivation early in the season may be grown between the rows. Lettuce, radishes, early cabbage, beans, and cauliflower are well adapted to this purpose, as they can be harvested before the dewberry canes become very long. If the soil has been properly fitted and the plants grow well, the canes should begin to spread over the ground by July or August. Intercrops that require cultivation later than August should not be grown, as the young canes are likely to be injured.

CULTIVATION.

Cultivation should begin immediately after the plants are set. In some sections cultivation should be as frequent as once each week during the first season, in order to keep the ground moist and the plantation free from weeds. In others, such frequent cultivation will not be necessary, once every 10 days being sufficient. When the canes which are allowed to trail on the ground for the first year begin to interfere, cultivation is discontinued and nothing further done in the field until the following spring except in sections where winter protection is necessary. If later cultivation is required the canes should be carefully pushed to one side. Any work among the plants during the autumn or winter is likely to injure the canes, which become very brittle and when loaded with fruit are very easily broken. If they are bruised, they may break off at the bruised point during the next fruiting season and the fruit be lost.

In most sections the canes are tied to stakes or wires before growth starts in the spring. Cultivation should be started immediately after growth begins and continued at frequent intervals until the new canes begin to interfere with cultivation, which is usually some time in August. In the New York section, however, cultivation usually ceases by picking time. Weeds which come in later are left to protect the canes in winter.

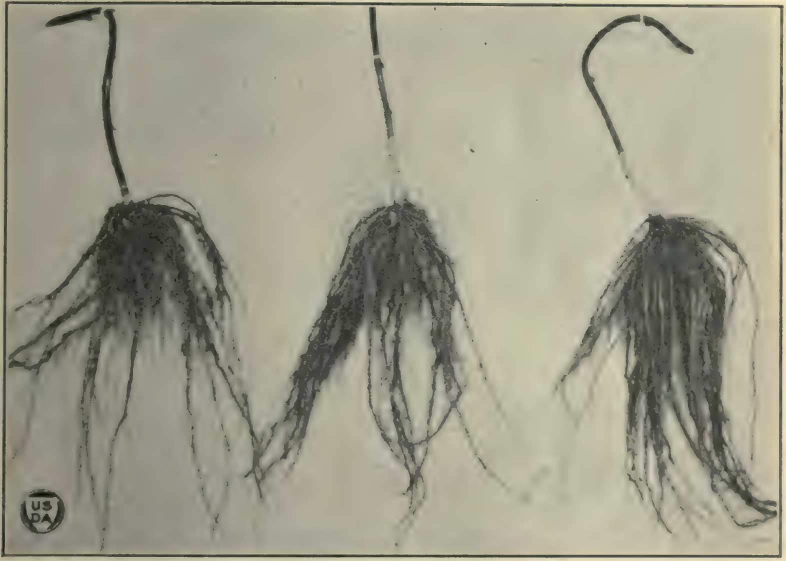

FIG. 3.—Tip-rooted Lucretia dewberry plants ready to be set.

COVER CROPS.

At the last cultivation some growers sow a cover crop broadcast in the plantation, to be turned under the following spring. In sections where cowpeas are used, one or two rows are drilled between the rows of berry plants. Wherever possible cover crops should be used, as they help to protect the canes during the winter, prevent the land from washing, and add humus to the soil. If cowpeas are used and the vines grow very long, they may increase the expense of tying up the canes in the spring, but the value of the cover crop will usually more than offset this.

FERTILIZERS.

The use of fertilizers in dewberry fields must be governed by the same principles that apply to their use with other fruits. As soils vary in the quantity and availability of the plant food they contain, the fertilizer problem is a local one which each grower must solve for himself. By varying the quantities of the different elements of plant food on different plats and keeping a record of the yield, each grower can readily determine what kinds and quantities of fertilizers to apply.

In one section of North Carolina dewberries are grown on coarse sandy soils. These soils as a rule are lacking in all the elements of fertility, and the application of a complete fertilizer is usually necessary. Although larger quantities of fertilizer are applied than may be generally necessary, the following description of the practices of successful growers in this section may prove of interest:

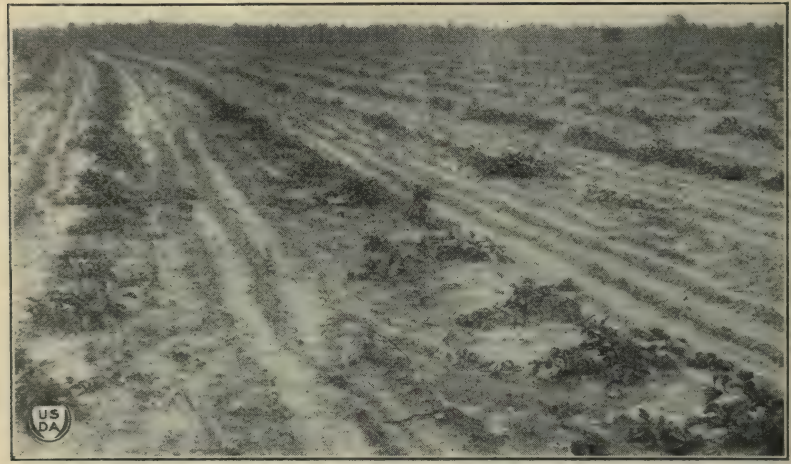

FIG. 4.—A field of Lucretia dewberries in New Jersey in their first season's growth, following spring planting. Photographed July 30.

As soon as the plants have become established and are 2 or 3 inches high, cottonseed meal or stable manure is used to encourage a vigorous growth the first season. Some growers use about 500 pounds of cottonseed meal, while others use 10 to 15 tons of stable manure per acre.

After the first season two applications of fertilizer are given each year, the first one being made as soon as the canes have been tied up in the spring. At this time a complete fertilizer is usually applied, composed of 2 or 3 per cent of nitrogen, 10 per cent of phosphoric acid, and 8 per cent of potash. Some growers, having found that they do not need nitrogen for their soils, apply only potash and phosphoric acid. The quantity applied likewise varies with the soil and with the different growers, but 500 to 700 pounds per acre of a fertilizer analyzing 2–10–8 are commonly used.

The second application of fertilizer is made immediately after the fruit has been picked and all the canes, both old and new, are cut off, the object being to induce a rapid growth of vigorous new canes for the next year's crop. A fertilizer containing a large proportion of nitrogen is used at this time. Either stable manure or cottonseed meal is commonly used. An application of 500 to 600 pounds of cottonseed meal per acre is considered sufficient, although there are growers using as much as 1,000 pounds. Growers using stable manure consider an application of 10 to 20 tons per acre sufficient. In addition to supplying nitrogen, stable manure adds large amounts of humus to the soil and is preferred when it can be readily secured.

The practices mentioned above are those used by successful growers in North Carolina and should prove helpful to growers in other sections in determining the applications for use under their particular conditions.

SYSTEMS OF TRAINING AND PRUNING.

The system of training to be used depends upon the climate, the cost of materials, and individual preference. In general, where suitable stakes can be secured for a reasonable price, the system of placing one at each hill and tying the canes to it will be most satisfactory; but in sections where stakes are very expensive some cheaper method must be used. Figure 6 shows a field with the plants 5 feet distant in rows 5 feet apart and a stake driven beside each plant. Under this system the plants are farther apart than under other systems. The expense of cultivation will be less, as more can be done with horse labor and very little hand hoeing will be needed. Picking will be much easier than under most other systems and fewer berries will be lost.

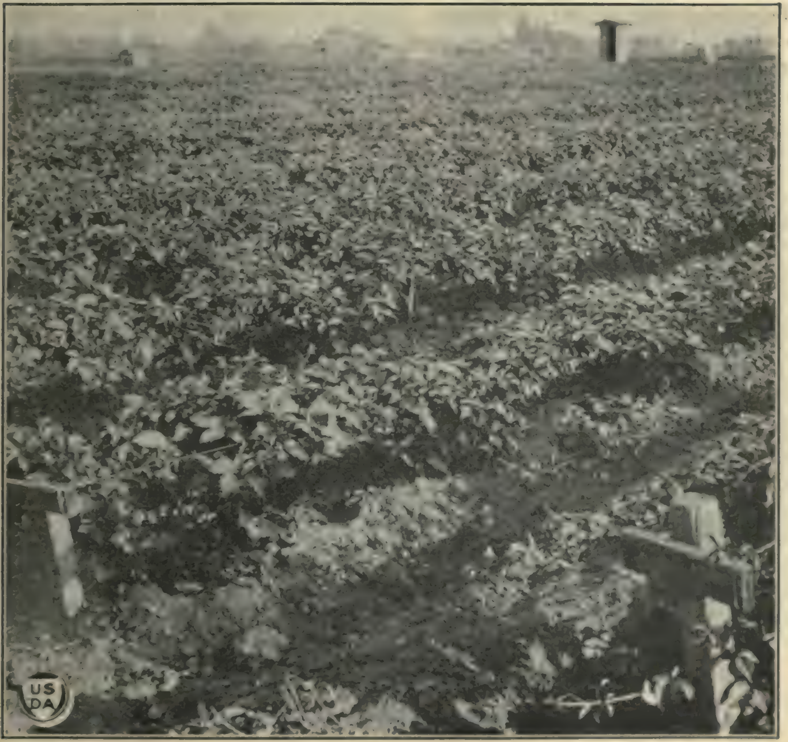

FIG. 5.—Dewberries trained to two low wires. Photographed near Los Angeles, Calif.

Under North Carolina conditions, where the canes grow vigorously, the stakes should be from 7 to 7½ feet long. There the stakes are made from yellow pine and are about 1½ by 1½ to 2 by 3 inches in size. In other sections stakes of any kind of wood that will not decay quickly in the ground are used. These stakes, placed about 3 inches to one side of the plant, are driven about 18 inches into the ground. The canes are tied to the stakes in early spring. This is done before growth starts, but after danger of severe freezing weather is past. Gloves are used in gathering the canes in a bundle and winding them around the stake in a spiral, as shown in Figure 2. The canes are tied to the stake in two or three places, once at the top, and either once more halfway up the stake or in two places distributed along the stake. Soft string must be used for this tying, as a small, hard string is likely to break the canes. The ends of the canes are cut off about 6 inches beyond the upper tying. The ends are often bowed before tying, to prevent slipping down the stake, as shown in Figure 7.

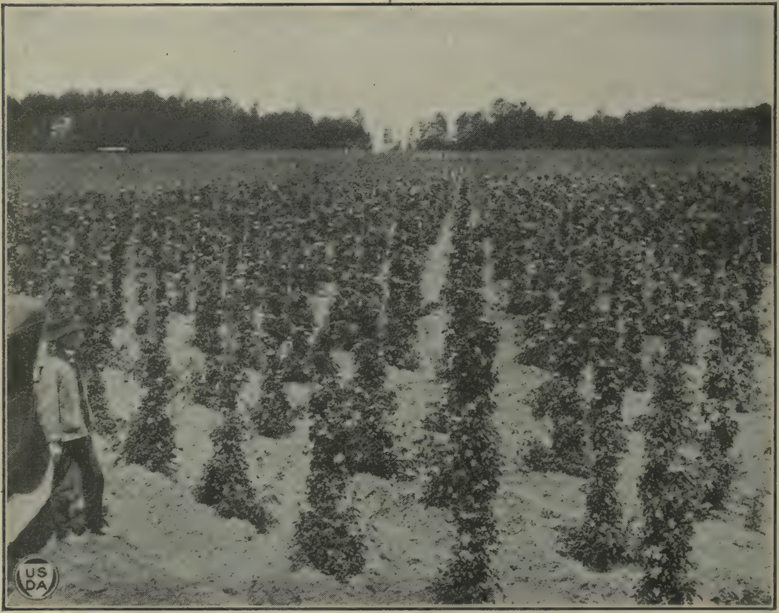

Fig. 6.—A Lucretia dewberry field in North Carolina, with the plants set 5 by 5 feet apart and the canes trained to stakes.

In New Jersey the canes are commonly trained to stakes as in North Carolina, but the stakes are much shorter, as shown in Figure 8.

In North Carolina and in other States having a similar growing season, all the canes, both old and new, are cut off as close to the crown of the plant as possible immediately after the fruit has been picked. Figure 9 shows a tool used for this purpose. If there is a severe drought this cutting should be delayed until after a rain. The canes are removed from the field and usually burned. After they have been removed cultivation should start at once and be continued until the new canes begin to interfere. This will induce a vigorous new growth, on which the fruit for the following year will be borne. The new canes are allowed to run on the ground and are left there until the next spring, when they are tied to stakes in the same manner as the previous year's growth.

Sometimes, instead of single plants 5 feet distant two plants are used. These are set about a foot apart and a stake is driven into the ground between them, the canes of both plants being trained to it. This method of planting offers no advantages over a field with one plant beside each stake, provided such a field is properly treated.

Another similar system is shown in Figure 10, where the plants are set 3 feet apart in rows 5 feet apart. More plants are used to the acre by this method, and the yields recorded for such fields have been very much less than for the system where the plants are set 5 feet apart each way. More hand labor also is required under this system, and the training, though like that in the system described, is more difficult.

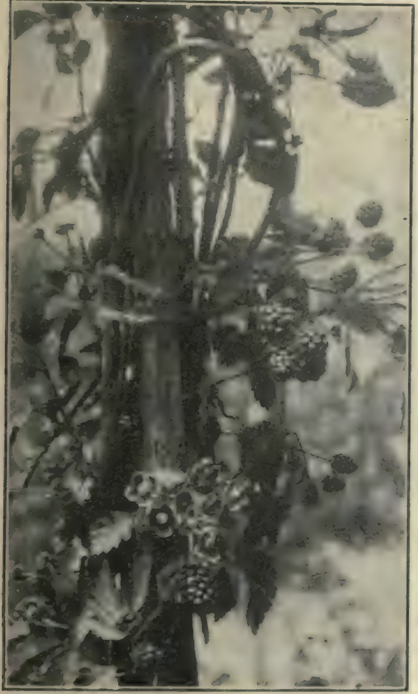

FIG. 7.—Dewberry canes, the ends of which have been bowed before tying at the top of the stake to prevent slipping.

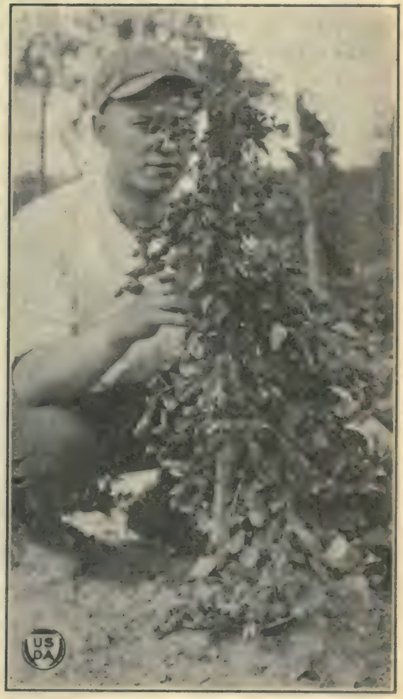

FIG. 8.—A Lucretia dewberry trained to a low stake in southern New Jersey.

Still another method is illustrated in Figure 11. Under this system the plants are usually set 3 feet apart in rows 6 feet apart. A stake projecting about 3 feet above the ground is set half way between two plants. Sometimes in the Central West the canes from each of the two hills are brought directly to the top of the stake, the canes from one hill tied to those from the other, and both sets of canes tied to the top of the stake. On the Pacific coast a stiff curved wire is sometimes used to help support the canes. One end of the wire is placed in one hill. It is curved over the top of the stake and fastened to it, and the other end is placed in the second hill. The canes from each hill are wound around this wire before being tied to the end of the stake. This system of tying the canes from two hills to one stake seems especially adapted to regions where the canes do not grow very long.

In southwestern Michigan and in the Germantown section in New York, where stakes are expensive, a wire trellis is often used. The plants are set about 2 to 2½ feet apart in rows 7 to 8 feet apart. Posts are set along the row, from 20 to 40 feet apart, depending on their strength and the vigor of the canes. In Michigan the posts project about 3½ feet above the ground, and a wire about 2½ feet above the ground is stretched along them. In New York the wire is about 4 feet above the ground and the posts correspondingly high. In both States the canes are gathered together in a bunch and tied to the wire, as shown in Figure 12. The ends are commonly cut off 8 to 12 inches above the wire. In Michigan sometimes, however, the ends are tied along the wire and left to bear fruit.

In some regions a trellis is made with two wires. The posts are set about 5½ feet high and the wires are strung one above the other, about 3 and 5 feet above the ground. The canes are tied to the wires, part along the upper wire and part along the lower. This method is rarely used except on the Pacific coast.

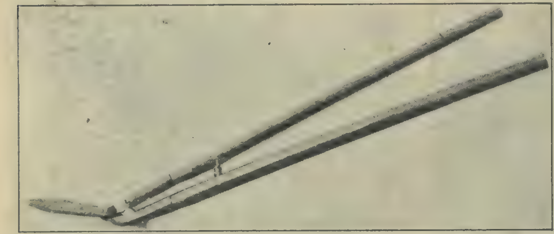

FIG. 9.—Long-handled shears used in North Carolina for pruning dewberries. The steel blades are curved upward, thus enabling the pruner to cut the canes close to the crown without much stooping.

In other regions neither stakes nor a wire trellis are used. The plants are set from 18 to 36 inches apart in rows 4 to 6 feet apart. Throughout the summer the plants are cultivated in one direction only. The tips are usually allowed to root at will along the row, but not between the rows. In Texas, where this system is used, it is necessary before picking to go over the plantation with a sickle or knife to cut the new canes back. The canes interfere with the pickers, and the cutting back does not injure the plants. After the crop has been harvested the canes are mowed as close to the ground as is possible with a machine. When dry they are burned without being removed from the field. This cleans the field of diseases and insects that may be on the canes, besides saving the cost of removing the old canes. The fields are then cultivated during the remainder of the summer, and the new canes are allowed to make a solid row.

Occasionally in Texas a plow is used to cut off all the plants just below the crowns. This removes all diseases and insects in the crowns, and the new canes spring directly from the roots. These canes will not be as strong as those from the crown, but will bear a good crop the following year and a full one the second year. In Texas many dewberry fields when trained in this manner are mulched during the winter or spring with prairie hay. The berries are borne so near the ground that a thick layer of this hay is needed between the rows to protect both the pickers and the berries from the soil in case of rain. It also helps to conserve the moisture. After picking is over the hay can be placed on the rows to help burn the old canes. Sometimes as the new canes come up, the ends are pinched back so they will form a small much-branched bush.

In Colorado no trellis is used and the plants are trained in rows. When the young canes reach a height of about 18 inches they are cut back to about 12 inches, to force the laterals to start. Just before picking, the laterals are shortened to enable the pickers to get the berries easily. No further pruning is done until the following spring, when the dead canes which fruited the previous season are removed and the live ones shortened to about 3½ feet. Under this system clean picking is difficult and many soft berries are liable to be put into the baskets, as the fruit is often partially concealed by the foliage.

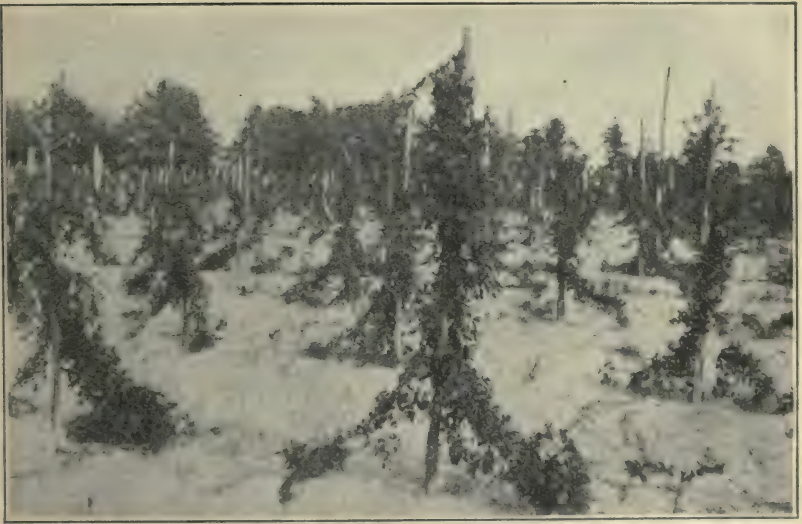

FIG. 10.—A Lucretia dewberry field in North Carolina, showing plants set 3 feet apart in rows 5 feet apart and the canes from two plants trained to one stake. Photographed June 8.

Variations of this system are in use. Stakes projecting about a foot above the ground are set about 10 feet apart along the row, with a wire strung on the tops of them, and the canes are thrown over the wire, as shown in Figure 5. Sometimes two rows of stakes about 12 inches apart, with wires as in the single row of stakes, are used. The canes are simply allowed to grow over the wires.

WINTER PROTECTION.

In the Southern States, and in most of those States where snow covers the ground through the winter, no protection of the canes is necessary, as they trail close to the ground. In some parts of the Central Western and Northern States the canes must be protected during the winter.

In the Michigan section this is usually accomplished by covering the canes with 2 or 3 inches of earth. Growers there cover the first 2 or 3 feet of the basal growth, while many believe that all the canes to be saved for fruit bearing should be covered. If the plants are in solid rows this can be done very cheaply by turning a furrow about 3 inches deep on the plants. The canes should be covered before there is danger of hard freezes and uncovered in the spring after the danger of freezing is past. In the Germantown section of New York, protection is afforded by allowing weeds and grass to grow in the fields, and as these die in the fall they cover much of the growth.

HARVESTING.

Dewberries are picked and handled in the same manner as blackberries. They are usually picked in quart baskets and sent to market in crates holding either 16 or 32 baskets. Figure 13 shows a crate of Lucretia dewberries. The same care should be observed in handling dewberries as in handling blackberries. The fruit should be picked at regular intervals, usually every other day. In some sections in very warm weather it will be necessary to pick every day, while in cooler weather three or four days may intervene between pickings. All ripe berries should be picked, because if any are left they will be too soft at the next picking to be shipped with the other berries. These overripe berries, as well as injured or bruised berries, will decay more rapidly than sound ones and may cause all the adjacent berries in the basket to decay.

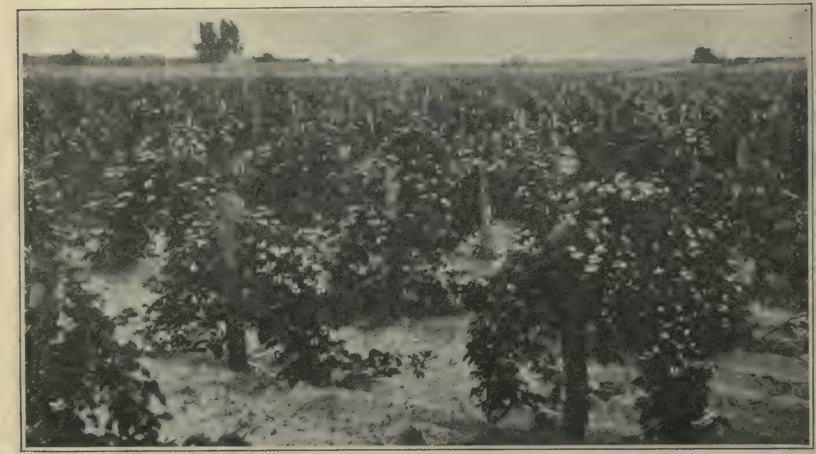

FIG. 11.—A field of dewberry plants in eastern Maryland trained to posts. The canes of two plants are tied to the top of one post. Photographed May 26.

In North Carolina young plants carry their fruit well distributed up the stake, but as the plants become older more short laterals are produced near the base and a mass of fruit is borne there, as shown in Figure 14.

The picking carriers shown in Figures 15 and 16 are very useful. The waist carrier is used only when the canes are tied to stakes.

YIELDS.

The yields of dewberry plantations vary greatly with the different conditions under which they are grown. The results obtained by growers in North Carolina indicate the possibilities. Crops of 100 crates of 32 quarts each per acre are obtained there by some, year after year, and the better plantations often yield 150 crates. Though the average yields may be somewhat smaller, good plantations favorably located should yield as much. Some growers average much more, but these men show exceptional ability or have exceptional conditions. Figure 17 shows part of a field of the Lucretia variety, now 12 years old, which has averaged more than 100 crates an acre per annum since coming into bearing.

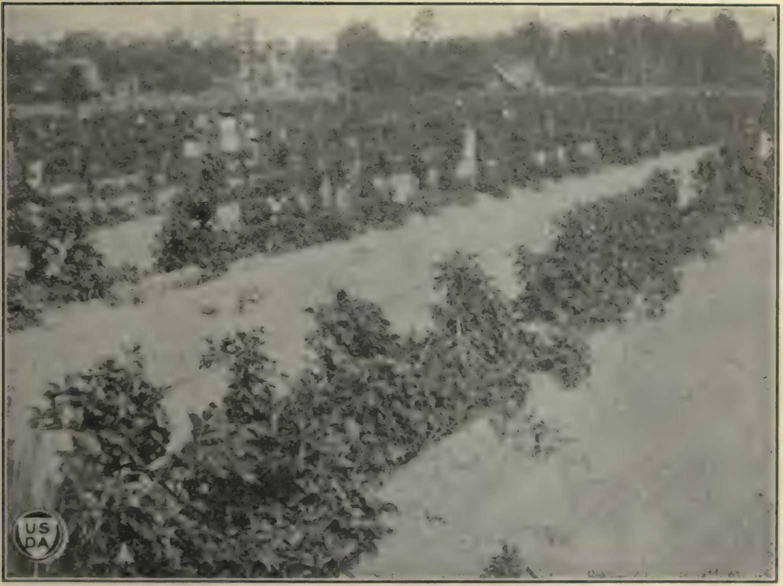

FIG. 12.—Lucretia dewberries trained to a 1-wire trellis. All the canes are gathered in a bundle, tied to the wire, and the canes cut off about 6 inches beyond. This system is the principal one used in southwestern Michigan and in eastern New York.

In North Carolina, 1-year-old fields in good condition often yield 35 to 50 crates per acre and a full crop when 2 years old. In Michigan no crop is expected until the second year and a full crop the third or fourth year.

DISEASES AND INSECTS.

There are two serious diseases of the dewberry, anthracnose and double-blossom. Other diseases which may cause considerable trouble are the common leaf-spot, root rots, and the cane rust. Dewberry growers at present pay little attention to the last three diseases, though they undoubtedly cause considerable injury at times. The anthracnose and double-blossom are more serious and are controlled in southern sections by cutting off all the canes, both old and new, immediately after harvesting the crop; in fact, this cutting out of all the canes after the harvest is considered by southern growers as the most important operation in dewberry culture. In North Carolina the canes should be cut as close to the crown as possible and removed from the field. By thorough cultivation and the use of fertilizers vigorous new canes free from these two diseases will be grown by fall for bearing the next year's crop. In Texas the common practice is to mow the field after harvesting the crop and to burn the canes in the fields. Sometimes a bush scythe or sharp hoe is used for cutting the canes. Wherever the growing season is long enough to allow sufficient new growth to mature before winter to bear the next season's crop, either the North Carolina or Texas method should be used. Anthracnose is a serious disease in nearly all parts of the country. Where the canes are not cut off after picking, a dormant spray of lime-sulphur should be applied just before growth starts in the spring. Double-blossom is common in New Jersey, Tennessee, and States south of them and as far west as Texas. This disease is controlled in sections where the canes are not cut off after picking by removing all buds which show infection in the spring.

Insect attack is not usually serious on dewberries. Specific information in regard to both insects and diseases may be secured by writing to the nearest State agricultural experiment station or to the United States Department of Agriculture, Washington, D. C., and furnishing specimens of the affected parts.

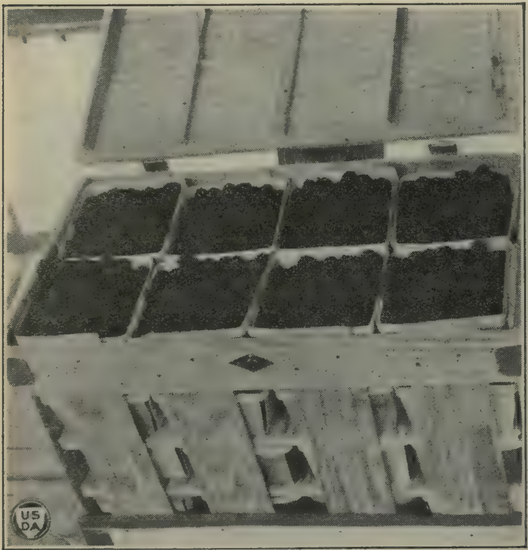

FIG. 13.—A 32-quart crate of Lucretia dewberries grown in North Carolina.

PROPAGATION.

Plants may be procured from any reliable nursery at a reasonable price, and in starting a plantation this procedure is usually followed. Dewberry growers already having a plantation usually raise their own plants by covering the tips of the young canes with a few inches of soil late in the summer or early in the autumn. These tips will root freely, and new plants will be ready to dig late that fall or early the next spring. A rooted tip should be cut off 4 to 6 inches from the ground when desired for planting. Only the strongest plants should be set.

Sometimes the dewberry is propagated by means of root cuttings. When this method is used, pieces of the larger roots about 3 inches long are planted 2 or 3 inches deep. If the root cuttings are placed in moist but not wet sand in the late autumn they should have calloused by spring. They should then be planted in the nursery row to grow for one year, after which they are ready to set in the field. This method is not often used, as rooted tips are obtained so easily.

DURATION OF THE PLANTATION.

The duration of the plantation will doubtless depend on the section of the country in which the dewberries are grown, on the system of training used, and on the attention given it. In North Carolina, plantations 15 years old are still productive. A few fields even older are still yielding well, but most of them have been planted too recently to make possible an accurate estimate of their probable life.

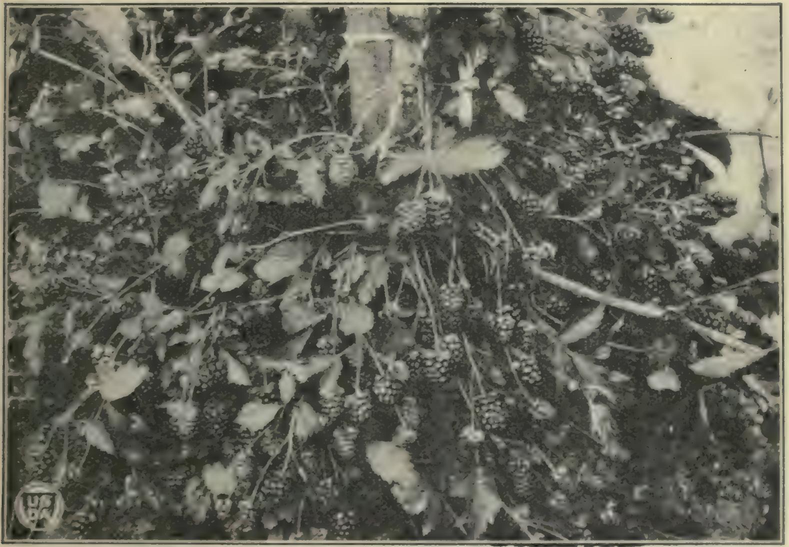

FIG. 14.—A dewberry plant in North Carolina having not only a rope of fruit up the stake but a mass of fruit borne on short laterals at the base.

POLLINATION.

It has been found that when certain varieties of dewberries are planted by themselves no berries will be formed. The reason is that the flowers of such varieties do not have pollen that will fertilize their pistils. Some variety having flowers that open at the same time and bear an abundance of good pollen must be planted near them. Bees and other insects will then carry the pollen from the flowers of one variety to those of the other. The Gardena, Lucretia, and Mayes varieties are usually self-fertile and may be planted by themselves without provision for cross-pollination. The Premo and some other varieties less widely known, such as the Chestnut, Manatee, and Rogers, are reported to be not entirely self-fertile, and should be planted with other varieties as pollinizers. The usual method is to plant two rows of one variety; then two rows of a second variety.

VARIETIES.

Very few varieties of dewberries are widely grown in the United States, the Lucretia being the leading variety except in the Gulf Coast States. In Texas the Mayes is the leading variety, while in the other Gulf Coast States very few dewberries of any kind are grown. In California the Gardena is raised to a considerable extent. The following notes will indicate the more important characteristics of the leading varieties.

Gardena.—This variety has become very popular in California, but has not been extensively tested in the East. In California the canes are very productive, the berries large, long, of very good quality.

Lucretia.—This is the best known and most widely grown dewberry. The canes are very vigorous and productive. In protected locations this variety is hardy in the Northern States. In Iowa, Minnesota, Colorado, and neighboring States it is usually protected in winter by covering with soil. The canes are susceptible to anthracnose and double-blossom. The berries are large, long, firm, of good quality, and are picked for shipping as soon as they turn black, but they do not become very sweet unless they are left on the plants a day or two longer. They ripen about June 1 in the North Carolina section and are later than the Mayes or Premo varieties.

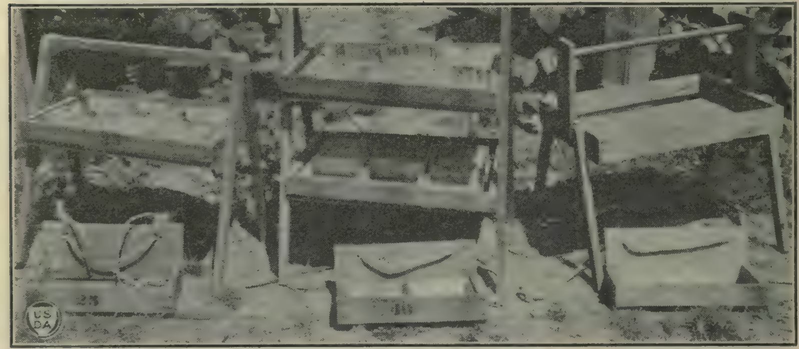

FIG. 15.—Different types of waist and hand carriers used chiefly in picking raspberries and blackberries.

Mayes (synonym, *Austin Mayes*).—This variety originated in Texas and is the leading one in that State. It has been grown to a slight extent in many other States, but although considered more productive and earlier than the Lucretia it is too soft to ship far. The canes are vigorous, productive, and subject to double-blossom and anthracnose. The berries are very large, not as long as the Lucretia, and have large drupelets. (See fig. 1.) Although soft for shipping, they are of excellent quality. The variety ripens at least a week before the Lucretia and slightly earlier than the Premo. A thornless sport of this variety has been reported, which should be especially desirable.

Premo.—The Premo has been grown to some extent in the dewberry section of North Carolina and in other parts of the eastern United States. It ripens its fruit in North Carolina nearly a week earlier than the Lucretia. The plants resemble the Lucretia very closely, but are not so productive. The flowers are imperfect, and plants of one of the other varieties must be set near to pollinate this variety. The berries average slightly smaller than the Lucretia, but are as firm and as good in quality.

HYBRIDS AND RELATED FORMS.

Several other varieties of dewberries are grown to a slight extent, some of which give promise of being available in certain limited sections. There are also several blackberries and blackberry-dewberry hybrids, which are sometimes, or usually, trained like the dewberries. Thus, the McDonald, a blackberry-dewberry hybrid, listed with blackberries in a previous publication,[3] is trained in the same manner as the dewberries in Texas. Farther north it is commonly trained in a manner similar to that of the ordinary blackberry. It ripens nearly 10 days before the Lucretia and may be planted in dewberry sections with the Lucretia as a pollinizer for it. The Mammoth, another blackberry-dewberry hybrid listed in Farmers' Bulletin 1399 and grown on the Pacific coast, trails on the ground like the dewberries. It is, however, somewhat more vigorous and should have a pollinizer. On the Pacific coast and in New Jersey the Evergreen blackberry (*Black Diamond*, *Star*, *Wonder*, *Ewing Wonder*, *Atlantic Dewberry*) is trained by a method similar to that used for dewberries. In New Jersey it is trained to stakes, such as are illustrated in Figure 17, or a trellis. In Oregon and Washington it is trained to a wire trellis.

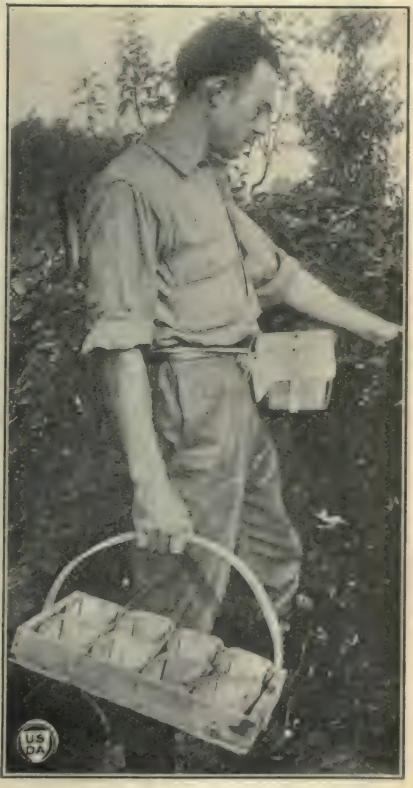

FIG. 16.—A hand carrier for holding six quart or eight pint baskets. The waist carrier shown is designed to hold a quart basket, leaving both hands free for picking where tall stakes or a high trellis are used.

SUMMARY.

The dewberry, although closely related to the blackberry, is distinguished from it by having trailing canes that root at the tip and in having small flower clusters, while the canes of most blackberries are erect, do not root at the tip, and the flower clusters are large. The dewberry is grown for its fruit, which ripens earlier than that of the blackberry.

At present the dewberry is grown more widely in North Carolina and New Jersey than in other States, but it is adapted to nearly all parts of the country. Although suited to many types of soils, it is grown most extensively on coarse sandy loams. Its deep rooting system enables it to obtain moisture from such soils better than many other crops.

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[3] Farmers' Bulletin 1399, Blackberry Growing.

The plants are usually set in early spring, either 5 feet distant each way, or 2½ to 3 feet apart in rows 4 to 7 feet apart, depending on whether the hill system of culture or the solid-row system is used. Until the canes begin to interfere, thorough cultivation is given the first season.

The following spring, just before the buds start, is the usual time to train the canes. In North Carolina and in some other States where the hill system is used, stakes about 2 inches square are set by each plant and project about 5½ feet above the ground. The canes are then gathered together, wound in a spiral about the stake, and tied with coarse string. After the crop has been harvested, both old and new canes are cut off at the surface of the ground and removed from the field. This cutting out of the old canes removes all the diseases on them, and the new canes are usually free from disease.

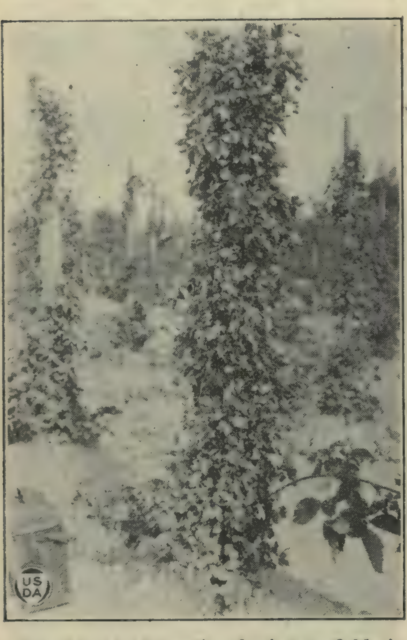

FIG. 17.—A Lucretia dewberry field in North Carolina set in 1903 which has averaged more than 100 crates per acre since coming into bearing. Photographed June 10.

Where the solid-row system of culture is employed many methods of training are used. In many places a post about 3 feet high is set between every two plants. The canes from each of the two plants are brought to the top of this post and tied to it, the projecting ends of the canes being then cut off.

In regions where posts are expensive a wire trellis is often used. Posts are set along the row from 20 to 40 feet apart, and a wire about 2½ feet above the ground is stretched along them. The canes of each plant are gathered together and tied to the wire.

In southern regions, where the seasons are long enough to allow sufficient new growth to appear, all the canes, both old and new, are cut off after the fruit has been picked. In northern regions, where sufficient new growth can not be obtained, the old canes only are removed at this time.

In some places where the solid-row system is used the canes are allowed to run on the ground or are thrown over a low wire about a foot above the ground. This makes picking more difficult, but saves expense in training. In Texas and some other Southern States where this method is used the canes are mowed off at the surface of the ground and burned. This cleans the field of disease, and the new growth of canes is much healthier.

The Lucretia is the variety principally grown and is generally the most desirable. The Mayes is the leading variety in Texas, but its fruit is softer than that of the Lucretia. The Gardena is grown to some extent in California.

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U. S. DEPARTMENT OF
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FARMERS' BULLETIN No. 1404

PUMPING FROM WELLS for IRRIGATION

MANY THOUSANDS of farmers in the arid and semiarid States have no dependable water supply except what can be secured from the underflow. Large areas of land now devoted to grazing may and doubtless will be eventually devoted to intensive farming by the utilization of the underground-water resources. The sinking of a well which will produce an ample supply of water and the installation of an efficient and economical pumping plant require skill and knowledge not ordinarily possessed by the farmer. The purpose of this bulletin is to guide aright those interested in pumping from wells for irrigation by making available the most essential information pertaining to well construction and the selection, installation, and operation of pumping plants.

Washington, D. C. **Issued May, 1924**

PUMPING FROM WELLS FOR IRRIGATION.[1]

By Paul A. Ewing, *Assistant in Irrigation Economics, Division of Agricultural Engineering, Bureau of Public Roads.*

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INTRODUCTION.

Less than 2 per cent of the total land area of the arid and semiarid sections of the United States is now irrigated, yet reclamation has reached the stage where future progress can be made only through the construction of extensive storage works or the use of underground waters. As storage works require large investment of capital, which implies some form of community effort, the only opportunity for further advance as a result of individual initiative lies in the recovery of underground water.

Water pumped from underground sources is destined to play a more important part in the irrigation of land in the United States than it has hitherto, but it is well for the individual to bear in mind that not every underground supply is suitable for irrigation in quality or quantity.

The following considerations should have attention before money is spent for a well and pumping plant:

(1) Is the water suitable for irrigation?

(2) Is the underground water supply sufficient to meet the expected requirements?

(3) Is the pumping lift low enough to justify the expense of pumping for the crops to be grown?

(4) Have similar undertakings succeeded in the locality?

(5) Is the power supply to be used for pumping reliable and cheap?

(6) Have local business men, disinterested in the sale of pumping machinery or land, confidence in the feasibility of pumping for irrigation?

Besides considering these matters which have particular connection with irrigation by pumping, the farmer has also to give thought to other general phases of irrigation, such as the necessary preparation of the land, the adaptability of the soil for irrigation, the climate, the accessibility of markets, and the rates charged locally on borrowed money. These are discussed in other bulletins of the department.[2]

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[1] A compilation of contributions by F. L. Bixby, C. E. Tait, and Milo B. Williams, senior irrigation engineers; J. C. Marr and L. M. Winsor, irrigation engineers; P. E. Fuller, former irrigation engineer; and Prof. F. J. Veihmeyer, collaborator. Free use has been made of data and statements in publications of various State agricultural experiment stations.

SUMMARY.

The essentials of a satisfactory irrigation pumping plant using well water are: (*a*) An ample supply of water suitable for irrigation and near enough to the surface for economical pumping; (*b*) a pump which is adapted to the given conditions as to lift and quantity to be pumped; (*c*) an engine or motor that will deliver the required power to the pump with the minimum loss of efficiency and at the minimum cost; (*d*) the entire plant carefully planned and installed.

The farmer should engage the services of a reliable well driller and should see that a well-drilling contract is drawn up which will protect him against unwarranted expense and inferior work.

The well casing should be of a standard type, such as screw, riveted, or stovepipe casing, and the portion in contact with water-bearing formations should be perforated so as to admit water in sufficient quantities and screen out the sand and gravel.

Before pumping equipment is purchased the well should be thoroughly tested to determine its capacity and draw down.

The types of pumps most commonly used for irrigation are the horizontal and vertical centrifugal, the deep-well turbine centrifugal, the plunger, and the air-lift. The height through which the water is to be raised is the chief governing factor in the selection of the type.

The power may be supplied by an electric motor or an internal-combustion engine.

QUALITY OF THE WATER.

Certain dissolved minerals constituting what are known as alkali salts are sometimes present in well water in sufficient quantities to be injurious to vegetation. If there is any question as to the quality of the water an expert opinion should be obtained from the State agricultural college. Some crops are more tolerant of alkali salts than others, and this fact should be remembered when considering the suitability of water for irrigation.

WATER SUPPLY.

The amount of water required varies with the nature of the crop, the soil, the method of irrigation, and the climatic conditions. Deciduous fruit trees and vines require the smallest quantity. Forage crops and garden truck require the most. The range is from less than 1 foot to about 4 feet in depth a year. A close estimate of the depth required can best be made by observing the irrigation practice of the locality, but if there is no good example at hand results obtained under similar conditions in other sections may be taken as a guide.[3]

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[2] Farmers' Bulletins 863, 864, 882, 899, 1243; Department Bulletins 1047, 1048; Department Circular 197; Monthly Weather Review; Field Operations of the Bureau of Soils.

[3] See Farmers' Bulletins 863, 865, 882, and Department Bulletin 339 for discussions of the irrigation needs of various crops.

Before considering the adequacy of a well as a source of water, it is necessary to know the depth of water required at each irrigation and the frequency of irrigations in order that the maximum rate of use may be estimated. Suppose, for example, that 40 acres is to be set out in fruit trees and that it has been found by a study of other irrigated orchards that an application 6 inches deep must be made during a certain time of the year within a period of 10 days, representing the maximum rate of irrigation. The well must then be able to supply 20 acre-feet during a period of 10 days continuous pumping, or in other words, the well must produce at the rate of approximately 1 cubic foot of water per second, or about 450 gallons per minute.

Unless an ample supply of underground water is known to exist, as evidenced by the successful operation of large pumping plants in the vicinity, each water-bearing stratum should be tested carefully during the boring of the first well. The ideal irrigation well is one which lowers 10 or 15 feet during the maximum rate of pumping, but returns within a foot or so of the original level a short time after the pump is stopped. There is, of course, a seasonal fluctuation of the water level independent of that caused by pumping, but unless the yearly demand exceeds the supply the water should return to its normal level or nearly so before the beginning of each irrigation season. A discussion of well testing will be found on page 9.

The possibility of obtaining a dependable water supply from wells is difficult to determine in any way except by sinking test wells. The Department of Agriculture places no credence whatever in "water-witches."[4] On high, arid or semiarid plateaus far removed from mountains and large rivers and with good surface drainage it is not likely that water will be encountered at any depth feasible for pumping. Prehistoric lake beds, such as are often found in the Great Basin area, rarely yield a good flow of water, as the gravels are in thin strata, generally interspersed with strata of clay and fine silt. On the other hand, in the valley of a large river with a sandy bed and on the adjacent benches or mesas the chances for striking water in sufficient quantities for irrigation are very favorable. The same is often true of a plain surrounded by high mountains and having no surface drainage or of a desert valley traversed by a wide, dry, sandy river bed carrying spring floods and occasional freshets.

A flow of 300 to 500 gallons of water per minute usually is considered an easily handled irrigation stream, but if less than 300 gallons is secured a small storage reservoir,[5] which may be filled during the night, will provide the necessary stream for the next day's irrigation if the pump continues to operate. Larger supplies often are furnished by a single well, or from batteries of wells pumped from one central station.

THE PUMPING LIFT.

The lift against which water for irrigation may profitably be pumped varies with the value of the crop to be grown. Under exceptional conditions water is lifted profitably 500 or more feet.

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[4] See Farmers' Bulletin 941, Water Systems for Farm Homes.

[5] See Farmer' Bulletin 828, Farm Reservoirs.

The last Federal census of irrigation reported an average pumping lift of 41 feet for many thousand plants throughout the West. The cost of pumping varies with the distance through which water is raised. It is best to avoid the possibility of failure by undertaking to pump water only where such ventures have proved profitable for the particular crop and locality.

LOCATION OF THE WELL.

If possible, a topographical survey should be made to locate the proper site for the plant and permit the laying out of a field system of distributing ditches or pipes. The pump should be located at the highest point of the land from which water may be conveyed economically through the ditches to all parts of the field, unless conveyance through pipe lines is planned, when a lower and more central location may be more desirable.

THE WELL CONTRACT.

Ordinarily the boring or digging of an irrigation well is provided for by formal contract to insure efficiency of performance by the well driller. The following suggestions, pertaining in the main to a well drilled by percussion methods, should have the attention of a farmer entering into such a contract.

A contract may specify the character of the apparatus to be used in sinking the well. There should be a difference of at least 2 inches between the outside diameter of the sand bucket and the inside diameter of the casing and the sand bucket should have a steel shoe with a flap valve of as great an area as the bucket will allow. Often a driller's outfit will include a dilapidated bucket possibly three or four inches in diameter and having a round, worn-out soft iron shoe, with a small valve in the bottom which is hardly one-half the size the bucket will allow; and, if permitted, he may attempt to sink a well 10 inches in diameter with the bucket.

In some sections of the West, it is customary for the well driller to furnish casing, starter section, and strainer, if one is used. If the casing is of the stovepipe type the gauge and quality of steel used, whether the casing be single or double, should be specified in the contract. The construction of the starter section should be set forth in detail, as should also the thickness of the drive shoe and the material of which it is made, its shape and temper, the gauge of casing and the length of sections used in the starter section and the manner of joining these together. The dimensions of the well should be set out, and the length and spacing of the perforations or the characteristics of the strainer described.

There are several ways of paying for such work. The usual way is at so much per foot for drilling, the scale of prices increasing with the depth of the well. It is usually specified that the first 25 feet shall be paid for at a flat rate per foot, with an increase per foot for the next 25 feet and so on to the full depth of the well. Most well drillers insist on inserting in the contract a provision for minimum depth of well, and as a protection for the farmer the maximum depth should be specified, so that the driller may not deliberately pass a desirable water-bearing stratum and drill to greater depth for the increased pay.

Several large well-drilling companies work for a specified sum per day for the use of the well-drilling rig. No charge is made for the time consumed in making repairs. Another arrangement specifies a lump sum for the drilling of a well of certain size to a definite depth. In such an arrangement the well driller usually sets his prices to protect himself, with more than necessary safety. Generally he can make a closer estimate of the probable depth of the well than the farmer. The extra chance he runs in contracting for definite quantities of water is reflected in his price. Such arrangements often have led to much dispute.

A precaution the farmer should take in entering an arrangement of the "no-water-no-pay" type is to insist that the draw down of the water surface in the well during the pumping test shall not exceed a specific limit, and that the test be continued long enough so that the accumulated head of water in the immediate vicinity of the well shall be removed, leaving only the normal supply which will come to the well after a long period of pumping.

The test should last long enough to clear the water. Inability to do this usually indicates improper perforation of the casing, an unsuitable strainer, or the collapse or rupture of the casing. The contract should call for the delivery to the farmer of a complete and detailed log of the formations encountered in sinking the well.

When working under contract the driller should be required to furnish bond or to advance all materials and labor, and should not receive payment for partial completion of the work. This protects the farmer in case it is necessary, through carelessness or mishap for which he is not to blame, to abandon the well and all or part of the casing. Usually it is advisable to set a time limit for the completion of the well.

In case it is anticipated that a turbine pump or other close-fitting machinery will be inserted in the well, the contract should specify that the bore of the well shall be straight enough to receive the machinery: or it may stipulate a minimum clearance between pump shell and inside of casing when the pump is in place.

WELL CASING.

Stovepipe casing is used in many water-bearing formations, but most successfully where coarse, unconsolidated materials are encountered. To avoid use of a strainer, the casing is perforated after the well is completed by tools which cut longitudinal slits or gashes from the inside. Screw casing also may be perforated and has the advantage over other casings that it may be pulled if the well is found to yield insufficiently. It is especially adapted to open-bottom wells in which it may be necessary to draw back to a certain formation after going beyond the desired depth, and may also be used in the sinking of wells, especially those of 12-inch diameter or smaller, where a strainer is to be inserted and the outer casing withdrawn.

Riveted casing is especially adapted to coarse-sand and small-gravel formations where driving or forcing is not necessary and where the water-bearing stratum is known to be unusually thick.

It may be perforated more effectively than screw casing, but it will withstand only a limited amount of perforation.

STOVEPIPE CASING.

Stovepipe casing consists of 2-foot sections and is usually made of steel sheets, with rivets spaced longitudinally of the section 2 or 2½ inches apart at the ends to 3 or 4 inches apart at the center. Each section of this casing, after being riveted, is placed in a machine or lathe and rotated against a facing tool to " true " the ends. For insertion in the well, a casing is assembled in short lengths as the well is drilled, but must be used double, there being a slight difference in the diameter of the inside and outside sections. An end joint of the inside section thus occurs midway of the outside section. Hence, when the lengths are together, the end faces butt evenly and squarely against each other and are held from slipping or telescoping by each other. Sometimes, as the lengths are assembled, they are profusely dented from the outside by a pick and are so kept from slipping apart or separating in the well in case the drilling tool should hang on the casing or on the shoes. Sometimes the sections are riveted together as a like precaution.

Stovepipe casing may be obtained in all diameters from 6-inch to 26-inch or larger. The 16-inch size is most used in irrigation wells.

A starter, usually consisting of eight 2-foot sections of casing of double or triple thickness riveted together and then to a drive shoe, forms the first section upon which rests the " string " of casing. If the material is fine and contains no bowlders or hard material, the 2-ply, 16 to 10 gauge starter, will be ample; otherwise the starter should be 3-ply. The drive shoe is slightly larger in outside diameter than the following casing, so cutting the hole larger than the casing and giving it clearance.

The drive shoes used with stovepipe casing are usually larger and heavier than those needed for other casing and have a shank which is riveted to the casing; the latter slips over the shank and butts against a shoulder on the outside of the shoe. Sometimes this casing is driven, for which operation a drivehead is used. This is composed of a heavy cast or wrought steel cap, recessed so as to fit the top of the casing snugly, and a pair of heavy clamps is bolted to the drill stem, which is raised and allowed to fall, as in the drilling stroke, the clamps striking the drivecap. Such casing has been put down as far as 200 feet in heavy bowlder formations by driving, though it is generally believed that it can not be sunk except with hydraulic jacks or levers, sometimes called " pries," which exert a steady and uniform pressure. Generally the use of hydraulic jacks is to be preferred to driving.

Stovepipe casing is likely to pull apart in fine sands unless it is riveted before being sunk. To prevent this a substantial footing for the casing must be found.

SCREW CASING.

Screw casings may be standard wrought-iron pipe with ordinary outside couplings. For heavy driving extra strong pipe, threaded to permit the ends to butt, and line pipe couplings should be used. " Inserted-joint " casing has one end of each length threaded inside after being expanded slightly, thus reducing the resistance when the casing is being lowered. Joints so made will stand very little driving. Casing may be obtained in a number of weights, such as light well casing, about half as thick as standard pipe, standard, and extra heavy pipe. When screw casing is used, whether with standard couplings or inserted joints, a steel drive shoe must be screwed or riveted to the bottom or upon the starting joint. Such a shoe should be of a thickness which will stand safely driving through hard strata or against bowlders. It is usually from three-fourth inch to 1 inch thick when used with large sizes of casing and from five-eights to three-fourths inch thick for sizes below 10 inches.

RIVETED CASING.

Riveted casing, composed of rolled-steel sheets, in sections from 14 to 24 inches in length, and plain or galvanized to resist rust, is frequently used. It is inconvenient to handle and will stand only light driving, and generally must be forced down by hydraulic pressure or a lever. It is often used in diameters over 20 inches for pits or dug wells, the weight of iron being proportioned to the diameter and the depth of the well. This casing usually may be obtained locally, especially in galvanized iron, which may be made at sheet-metal shops. If of heavy iron it must be obtained from boiler or sheet-iron manufacturers at prices varying according to the gauge.

If heavy-riveted casing is used it may be strengthened at the joints, the weakest parts, by butting the ends together and using inside or outside collars riveted to each section. This precaution is necessary if the casing must be forced into a hard formation, and some kind of a drive shoe at the bottom will be needed to prevent battering of the casing by bowlders or hard material.

STRAINERS.

Strainers have had their principal use in fine sand formations, but it has been found that where the water-bearing strata are of sand so fine as to call for special strainers wells are likely to fail anyhow, and the expense of strainers added to their uncertain action has led to discontinuance of their use in many sections. Gravel inserted in the well around the casing is now frequently used successfully in place of a strainer at much lower expense. (See p. 8.)

If conditions seem to call for use of a strainer it should be of a type known to be successful in similar formations.[6] Some water may be pure enough for irrigation but still contain enough salt to corrode certain metals to the extent of closing the openings, so rendering the strainer useless, and this fact should also be kept in mind when considering the use of a strainer.

PERFORATIONS.

Wells may fail to supply the amount of water they are capable of yielding because of insufficient perforation of the casing. While no definite rule can be given, it is recommended that as many perforations as possible be put into the shell of the casing opposite the water strata without dangerously weakening the casing. As much as 40 per cent of the metal can be cut away, but the proportion must be varied according to the shape and size of perforations, determined by the materials to be screened. Three or four slits should be made in each ring or circle, a space of 3 or 4 inches skipped, and a second ring or circle of slits then made, staggered from the preceding set. Under any conditions the proper perforating of casing in place is difficult to effect, and it would be well for the farmer to request a visible test of the efficiency of the apparatus before an attempt is made to perforate the casing underground. Many wells which do not produce sufficient water after the first set of perforations is made are much improved by repeating the operation.

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[6] For a description of strainers, see Water Supply Paper 257, U. S. Geological Survey, Well-Drilling Methods, by Isaiah Bowman.

THE DOUBLE-CASING WELL.

The double-casing or gravel-screen type of well is often very satisfactory in certain sections of the West. In drilling this well a large temporary casing is used. After the well is drilled a profusely perforated casing is centered in the temporary casing and as the temporary casing is withdrawn a screen of fine gravel or crushed stone is placed around the inner casing (see fig. 3). The gravel or stone filling should extend to the surface. Usually the screen should be at least 6 inches less in diameter than the temporary casing, to insure ease of insertion. If it is necessary to be sure of placing a continuous covering of gravel around the permanent casing a space of at least 4 inches should be left between the screen and the outer casing when the former is in place; otherwise the gravel may clog in spots and be distributed unevenly.

When properly made this type of well has many advantages over the type in which the casing is perforated in place, chief of which is the material increase in open space per linear foot of well. Moreover, the gravel screen is useful in fine sand formations in holding back a portion of the sand and so preventing caving. The continuous screen of gravel insures free entry of every stratum of water, whereas in perforating a casing after it is in place the perforator may miss some of the water-bearing strata unless accurate records are kept during the drilling process and careful measurements are made during the perforating.

This device requires that the temporary outside casing be jointed strongly enough to permit pulling from the well. Stovepipe casing will not withstand this operation, but is sometimes used as the outer casing, being left in the well with the inner casing and the inclosed gravel screen. Where this plan is followed the outer casing, which is of large diameter (18 to 24 inches), is first sunk and perforated opposite the water-bearing strata. The inner casing may be of the stovepipe type or a jointed pipe which is perforated during manufacture; if stovepipe casing is used it likewise is perforated before insertion. Crushed gravel is inserted between the two casings after both are in place. This makes an expensive installation, but one which has proved successful in many instances. It has the special advantage in some formations of affording a double protection to the bowls of a deep-well turbine centrifugal pump, which might be lost or rendered ineffective by the distortion or collapse of a single casing as the result of caving.

THE OPEN-BOTTOM WELL.

Many successful irrigation wells have been obtained in stratified formations, such as are found in the interior valleys of California, by making what is commonly known as an open-bottom well. In this type of well the bottom of the casing is open and all or part of the water enters through this open end. Such a well often is improved by perforating the casing to admit water from some higher stratum in addition to that coming from below.

The condition most favoring an open-bottom well exists where the lowest water stratum tapped underlies a hard, impervious material, such as clay, hardpan, or sandstone, in which the casing can be embedded firmly to form a foundation for the column and act as a seal to prevent water from carrying sand down from above, outside of the casing. The presence of the impervious layer or layers is essential to the success of the well. As an added precaution the hole bored through the hard stratum should be at least 2 inches smaller in diameter than the casing.

The impervious stratum acts as a roof over the water-bearing stratum from which, if it is fine sand, the fine materials will be pumped out gradually until a large cavity is formed in the bottom of the well. Under such conditions it is necessary that the impervious stratum be hard and thick enough to prevent serious caving. Should the roof give way under test, it will be necessary to drive the casing through the water-bearing stratum and embed it in hard materials below. Perforations can then be made opposite the water and the open-bottom well will be changed to a closed-bottom well.

WELL DEVELOPMENT AND TESTING.

A very serious and common mistake is made by the purchase of pumping equipment before the well is developed and tested thoroughly. Often wells increase in capacity with the first pumping. This is especially true when the water-bearing material contains fine sand, clay, or silt which can be removed by pumping. Heavy pumping is therefore often desirable before a test is run. It is impossible for manufacturers to supply efficient pumping machinery without accurate information as to the conditions under which the plant must work, and they should be furnished with the following information when their estimates of cost are requested:

(1) Inside diameters of the well with lengths of each size of casing.

(2) Total depth of the well.

(3) Depth to water table below the surface of the ground, and an estimate of probable seasonal fluctuations.

(4) The vertical and horizontal distances water must be pumped from the surface in the well with kind of pipe to be used.

(5) Distances water will drop in the well when different quantities are pumped.

(6) Probable economical draw down and ultimate capacity of the well.

The first four factors can be ascertained from the driller's log of the well and by direct measurements, but factors 5 and 6 can be determined only by a pumping test. Two plans for testing wells are practicable:

TEST PLAN NO. 1.

This is adapted to wells where the water level is 25 feet or less below the surface and general conditions indicate that, for the permanent installation, a horizontal centrifugal pump can be used on the surface or in a pit.

This test calls for a tractor or other temporary power, and a horizontal centrifugal pump sunk into a temporary pit in such way that a belt can be sloped to it from the tractor. A fair test of the average well may be obtained with a pump of about three-fourths the capacity of the permanent one. The smaller outfit will not develop a well as thoroughly as may be done by use of an oversized pump, but an accurate estimate of the rate of increased capacity per foot of draw down can be made, and from this information the proper economical draw down and final yield of the well can be estimated closely enough for designing purposes.

As the excavation and curbing are expensive, it is advisable for the farmer to put in a temporary curb. This may be 20 feet deep or less, to set the pump near the water table. A pump set about 5 feet above the water table is capable of handling a 15-foot draw down, which affords fair indication of future performance.

TEST PLAN NO. 2.

This is adapted to wells where the water table is 20 feet or more below the surface and general conditions indicate that the draw down will increase the lift to approximately 50 feet or more. It calls for a deep-well turbine pump or an air-lift outfit. Occasionally the best equipped well drillers have outfits of this kind, and where they are readily available plan No. 1 should not be considered, as the deep-well outfits are as advantageous in developing as in testing wells.

When conditions indicate that a turbine pump should be used for the final plant, manufacturers often agree to install a pump as near the proper size as they can select on the basis of the known conditions. The well is then tested, as in test plan No. 1, by driving the pump with a tractor or other temporary power. Such an arrangement is entered into with the understanding that the manufacturer will add or subtract bowls and column lengths of pipe at specified unit costs and refunds, as required by the conditions brought out by the test. The result of the test will indicate the horsepower needed to drive the pump most economically, and on this basis an engine of correct size should be installed or the belt head replaced with a direct-connected electric motor where electric current is available.

The average well should be developed slowly by controlling the discharge of the test pump with a gate valve. Where sand appears in the water first pumped, the plant should be run with a uniform discharge until the water begins to clear. Then the gate valve can be opened until larger quantities of sand appear in the water, this operation being repeated until the capacity of the pump or well is reached.

When this development process is started, everything should be in readiness so that there will be little likelihood of having to stop the pump before the well has been pumped thoroughly. This is especially desirable when fine sand must be contended with, as stoppage of pumping too soon may cause clogging of the well or pump. In other instances where difficulty is experienced in starting the flow, it may be advisable to fluctuate the discharge in order to agitate the water in the well.

After a well has been pumped for development for several hours to the maximum capacity of the well or of the testing apparatus and there is no apparent fluctuation in the discharge of water, a correct measurement of the flow should be made and the draw down below the static water level noted. The gate valve on the discharge pipe should then be partially closed until the vacuum gauge indicates approximately 4 feet of draw down below static level. (The vacuum gauge reads in mercury inches and to convert into feet of head the reading should be multiplied by 1.14.) After running about 15 minutes at approximately this level, the discharge and the draw down should be measured accurately and the valve opened until the gauge indicates 6 feet of draw down. This operation should be repeated with 2 feet draw down intervals until the capacity of the well has again been reached. In this way enough readings may be obtained to indicate the performance of the well at different lifts.

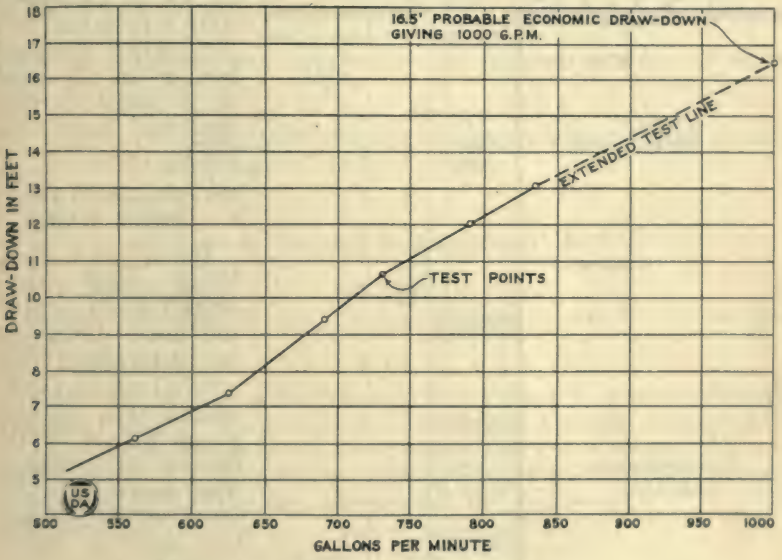

FIG. 1.—Typical well test chart.

The test should then be plotted graphically on a chart similar to that shown in Figure 1. The vertical scale represents draw down in feet and the horizontal scale discharge in gallons per minute. The rate of increase in flow per foot of draw down is indicated by the general slope of the line connecting the test points plotted on the chart, and the projection of the line beyond the last test point gives an indication of what may be expected if pumping be continued. In this way a safe economic lift can be assumed and the factors determined which are necessary for the design of machinery to fit the well.

The best way to measure the water is by use of a farmer's weir set, either in a properly designed box or in the bank of a small earthen reservoir made for the purpose.[7]

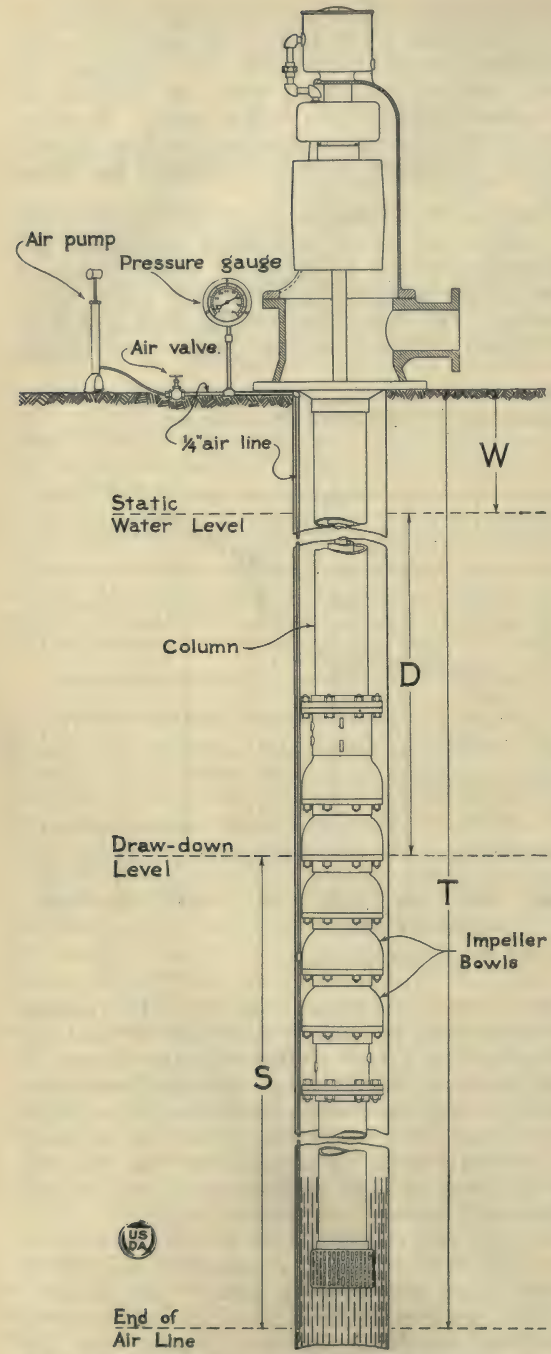

FIG. 2.—Electrically driven deep well turbine pump, showing apparatus for determining draw down.

DETERMINATION OF DRAW DOWN.

When a well is being tested with a centrifugal pump, the draw down can be determined approximately by means of a vacuum gauge placed on the suction ell or flange. The depth of water level below the gauge top may be determined by direct measurement, or from the vacuum gauge after the pump has been primed, unless a foot valve is on the suction pipe. In that case, if it is not feasible to make a direct measurement before the pump is started, the air-line measurement described later is a convenient method of getting the depth. In any case, the vacuum gauge indicates the draw down below the pump when the latter is discharging water.

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[7] See Farmers' Bulletin 813, Construction and Use of Farm Weirs.

Figure 2 illustrates a convenient and accurate way to determine the draw down where a test is made with a turbine pump. A one-quarter inch air tube of known length is placed in the well alongside the turbine. This tube should be long enough to reach below the level of the probable maximum draw down. To the upper end of the air line are attached a pressure gauge, an automobile inner tube valve or one similar, and a hand air pump, in such a way that all the water can be forced out of the tube and the air pressure necessary to do this read on the gauge. The gauge reading indicates the depth of the tube's submergence, and this, when converted into feet of head and subtracted from the total length of the tube, gives the depth to water below the pump at any stage of the test.

The following equations should be used in the test (see fig. 2):

Let T = Total length air tube in feet.
W = Depth in feet to static water level.
D = Draw down, in feet, at any stage of test to correspond with G.
S = Depth in feet to which air line is submerged.
G = Pressure-gauge reading, in pounds per square inch, at any stage of test.

(1) Then $T=W+D+S$.
(2) $D=T-W-S$.

As 1 pound pressure (gauge reading) $=2.31$ feet of head,
(3) Then $S=2.31\ G$.
(4) Substituting, $D=T-W-2.31\ G$.

When the pump is not running, $D=$zero, and W can be determined by
(5) $W=T-2.31\ G$.

For example, and referring again to Figure 2, it is assumed that the total length of air line, $T=100$ feet. Then to determine the distance to static water level, W, before the test is started, all water should be forced from the air line by use of the air pump, causing a gauge reading, $G=$say, $34\frac{1}{2}$ pounds per square inch.

Substituting values for T and G in equation (5)

$$W=100-2.31\times 34.5=20.30 \text{ feet}$$

To determine the ultimate draw down or the draw down at any stage of the test: The water is forced from the air line as in the preceding example and the pressure gauge G is read. It is assumed that the reading is 21.5 pounds per square inch.

Substituting values for T, W, and G in equation (4)

$$D=100-20.30-2.31\times 21.5=30.04 \text{ feet}$$

Should this value of D equal the ultimate draw down in a test, then the total lift in the well would be $D+W=30.04+20.30=50.34$ feet, and this value would be used in designing the plant.

BATTERY OF WELLS.

A battery of wells consists of several wells connected to a central pumping unit. A battery is desirable where water is to be pumped from shallow depths in fine formations; also where it is not feasible to admit water from several strata into the same well. Each well of a battery may tap a different stratum. Under such conditions the wells should probably be on lines radiating from the pumping plant. If the wells tap definite water-bearing strata, however, it is often best to locate them in a line at right angles to the probable direction of underground flow.

There are two ways of conveying water from a battery of wells to a central pumping unit: (1) By connecting all wells to the suction line; (2) where wells will flow into a porous water-bearing stratum, by pumping from this stratum.

In the first case, the most distant wells should not be more than about 200 feet from the pump. A surface or pit type of pumping plant must be used, depending upon the depth to which the water will draw down below the normal water surface when the wells are pumped. This type of plant should be designed very carefully and each suction line should be of the proper size. On long suction lines, a small air pump should be connected to the main suction pipe just before the latter enters the pump, to remove any air or gas that collects in the pipe.

The second case is best adapted to conditions where a deep-well pump is to be used and it is desired to augment an artesian supply with the ground water lying above an impervious stratum. It is probable that this method will be used oftener as pumping develops in those sections requiring drainage of the surface soil. Where large supplies are to be developed by either of the methods described, the advice of an engineer experienced in such developments should be secured before the work is undertaken.

PUMPS.

The horizontal and vertical centrifugal, the deep-well turbine centrifugal, and the plunger and air-lift pumps are the types most commonly used and best adapted to raising water from wells for irrigation.

HORIZONTAL CENTRIFUGAL TYPE.

Usually the horizontal centrifugal pump (fig. 3) is the cheapest in first cost and operation and the most reliable. Further advantages are: Comparatively light weight, lack of valves and parts that wear out rapidly, simple operation and maintenance, and high efficiency in raising large quantities of water through moderate lifts. It is especially adapted to pumping 250 gallons per minute or more where the suction lift is not over 20 feet and for pumping from a battery of wells when the lift is low. A centrifugal pump can not be operated when submerged, and it can not be used where the change of water level due to pumping exceeds 20 feet, the practical limit of suction lift, unless it is placed in a waterproof pit below the static water level. If the draw down of the water during pumping is not more than 40 feet below the ground surface, this pump can be installed in a pit and direct-connected to an electric motor or belt-connected to engine or motor at the ground surface. Fifteen feet is usually considered the maximum depth of pit for this type of pump when belt-driven.

When the total lift exceeds from 100 to 150 feet, the horizontal and the vertical centrifugal type described later are usually "staged." Staging means the multiplication of runners or impellers ,each of which repeats the work of the preceding one, the combination being capable of forcing the water through much higher lifts than can be done with a single-stage pump.

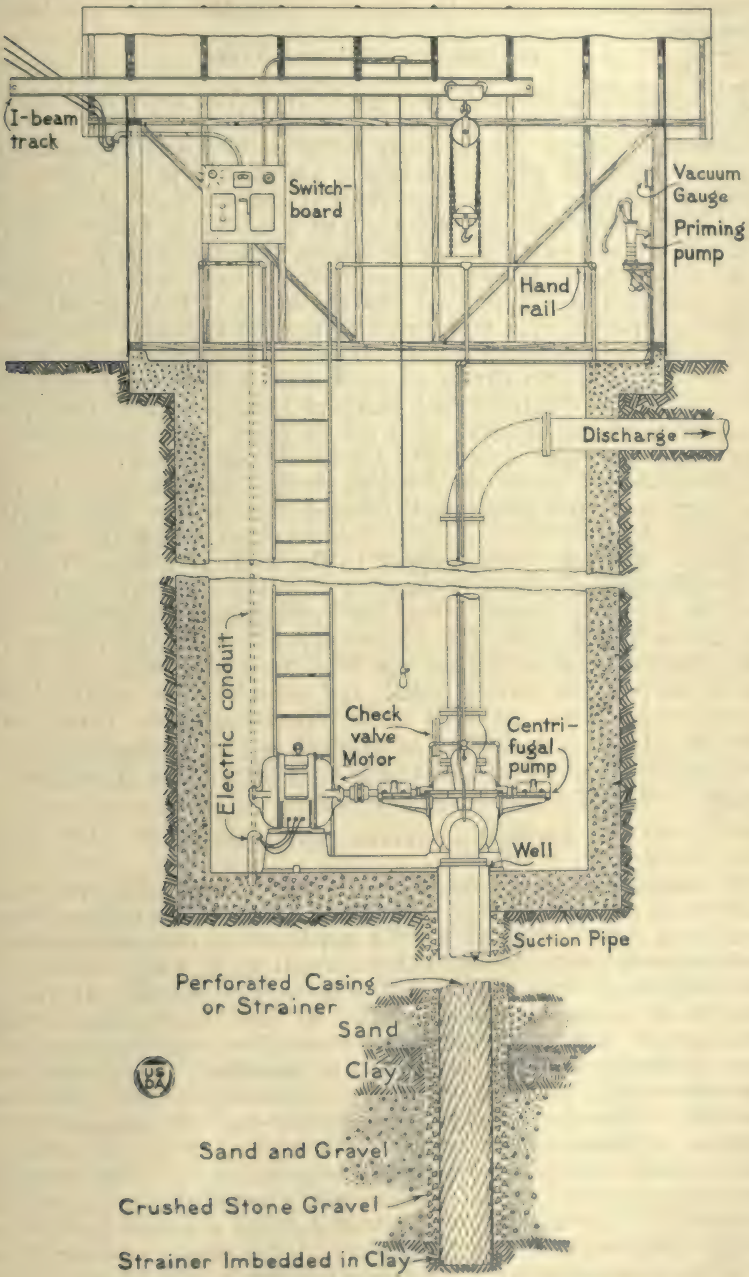

FIG. 3.—Electrically driven horizontal centrifugal pump in pit.

To maintain a constant discharge with lowering water level, the speed of the pump must be increased. This generally results in a decreased efficiency unless the runner is changed to fit the altered situation.

VERTICAL CENTRIFUGAL TYPE.

The vertical centrifugal type differs from the horizontal type in that the impeller is operated by a vertical shaft, which may be of considerable length. Many early wells in locations favorable for pumping were of 10-inch diameter, and this type of pump was especially adapted to such conditions if the lift did not exceed 50 feet. The pump is set in the bottom of a pit below water level and is driven by an electric motor or engine belt-connected to a pulley at the top of the shaft on the ground surface or, it may be, operated by a direct-connected vertical electric motor. The vertical shaft must be supported by a framework to prevent excessive vibration.

The chief advantage of a vertical over a horizontal pump is that it may be used with an internal-combustion engine for higher lifts, since the length of belt between pump and engine pulleys need never be excessive and a belt-way need not be built. This pump may be used where the water level fluctuates more than 20 feet, since it may be placed near or below the level of greatest draw down. In fact, the pump is usually submerged to lessen suction lift. On the other hand, the same restrictions as to the depth at which the pump is set due to pit construction apply to the vertical pump. The difficulty of effecting proper lubrication of pump and shaft bearings is likely to be troublesome. Vertical centrifugal pumps cost more than horizontal pumps of the same capacity. To the cost of the pump itself must be added the cost of a rigid framework with bearings to support the vertical shaft, and consideration must be given to the loss of power involved in the operation of the drive shaft, vibration of which is difficult to prevent as the bearings wear. In many sections, the use of this pump for irrigation is giving way to the deep-well turbine centrifugal pump.

DEEP-WELL TURBINE CENTRIFUGAL.

The deep-well turbine centrifugal pump, often called the "turbine" type, is much used in irrigation. It is similar to the vertical centrifugal type in that it has its impellers or runners incased in shells or bowls and is driven with a vertical shaft, which is not, however, supported by a framework. It usually consists of two or more bowls arranged tandem, 12 to 30 feet constituting a stage. (See fig. 2.) The name "turbine" comes from the diffusion vanes which guide the water from impeller to impeller. The principles of operation of this pump are the same as those previously described. The chief differences are its compactness and its adaptability to insertion in cased wells at considerable depths. Wells 10 inches in diameter and even smaller may be pumped, but with less efficiency than in the larger sizes, which occasionally are 24 inches in diameter or more. If the capacity of the well justifies a larger pump than will go into the well, the upper part of the casing is enlarged as far down as is necessary to accommodate the bowls and the suction is extended into the smaller casing, or in certain instances attached directly to screw casing. It is especially adapted to lifts varying from 50 to 250 feet.

The deep-well turbine pump has an advantage over the horizontal and vertical centrifugals in that it is far less restricted as to lift. Lubrication being effected from the ground surface, the depth at which the pump is set is limited neither by the expense of pit construction nor difficulty in attendance, but only by the cost of operation and by mechanical limitations of the pump itself. High lifts and large volumes of water are handled without difficulty. As in the case of the vertical centrifugal, the turbine pump is operated by means of an engine or motor at the ground surface belted to a pulley on the vertical shaft or is direct connected to a vertical motor incorporated in the pump head.

The turbine type is more expensive than either the horizontal or vertical centrifugal pump. It is not adaptable to pumping from two or more wells simultaneously. It is generally efficient and gives little trouble when properly installed. It is best suited to installations where the water level is more than 50 feet below the ground surface or in other circumstances where the water level fluctuates widely. Its principal disadvantage, besides its comparatively high first cost, lies in the expense and difficulty of making repairs, which usually involve the withdrawal of the entire pump from the well.

Manufacturers are likely to emphasize the ease with which this pump may be lowered to meet the requirements of a lowered water table, but this usually requires the installation of additional bowls or stages necessitating the removal of the entire pump from the well. Consequently, the expense of reassembling the pump and fitting additional bowls or stages should be considered in making a selection.

PLUNGER TYPES.

The plunger pump commonly used on the farm to raise water for domestic purposes may be utilized in irrigating very small areas. The plunger pump generally used and probably best adapted to pumping from wells consists of a brass cylinder in which operate two plungers with valves. (See fig. 4.) The lower plunger is connected to a solid rod which fits into a hollow rod to which the upper plunger is connected. The plungers are operated in such a way as to make the pump double-acting, one plunger being on its down stroke while the other is moving upward, so producing a fairly continuous discharge. Above the cylinder, and connected to it, is the vertical discharge pipe through which the water is forced by the action of the plungers. The pump is set in the casing with the plungers under water. At the surface of the ground the pump rods are attached to and driven by a power head, through gears, levers, or eccentrics. The power head, in turn, is driven by a motor or engine. The size of the cylinders ranges from 6 to 16 inches in diameter and the number of strokes varies from 16 to 24 per minute, ranging in length from 28 to 36 inches. By ingenious devices in some makes the downward stroke of each plunger is faster than the upward stroke. There is thus a lap in the strokes of the two plungers which does away with the tendency, otherwise present, for the flow of water to diminish when the two plungers are on dead center. A desirable feature of recent models is the sliding rail base on which the working head is built.

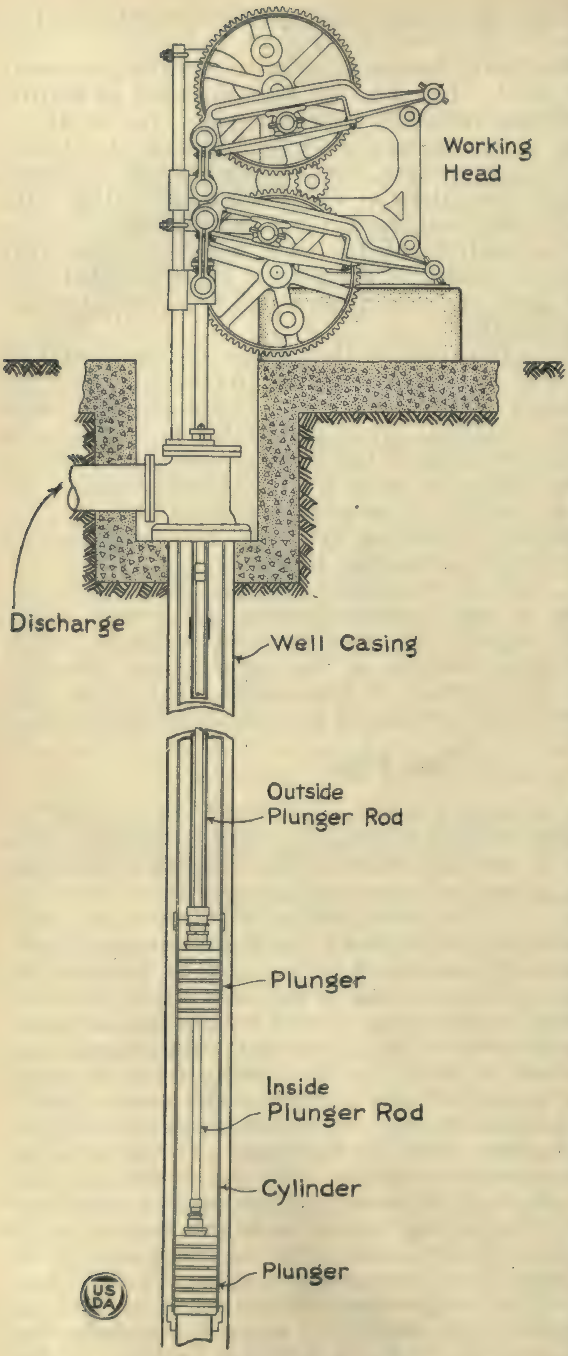

FIG. 4.—Electrically driven deep well plunger pump.

This permits the machinery to be slid back out of the way when the plungers or cylinder must be pulled.

The plunger pump is best adapted to irrigation where comparatively small quantities of water must be raised from great depths. When first installed, it has the highest efficiency of any pump, and under favorable conditions, if properly cared for, gives little trouble. On the other hand, its first cost is high. The leathers, valves, and cylinders wear quickly where sandy water is pumped, and if high efficiency is to be maintained, repairs must be made at considerable expense and loss of time. This type has its widest use in the irrigation of orchards in southern California, where small quantities of water are pumped against very high heads at an expense warranted only by the value of the irrigated crops grown there.

AIR LIFT.

The simplest type of air lift consists of a discharge pipe which is inserted into the well to a depth below the water surface of at least twice the vertical distance of the water from the ground surface; an air pipe extending from a compressor to the bottom of the discharge pipe and connected to it by a casting specially designed to distribute the air evenly; and a tailpiece which forms a slightly enlarged extension of the lower end of the discharge pipe below the point where air is admitted. The compressor forces the air deep into the water, where it is released and rises to the surface, forcing a quantity of water up with it.

The absence of complicated working parts beneath the surface of the ground is an outstanding advantage of the air lift. Sand and other material may be removed with the water without harm to the pump. If proper submergence is possible the pump may be adjusted to a lowering water level, and is particularly adapted to pumping several wells from a central power house. An air-lift pump is also adapted to a crooked well in which a turbine pump can not be set.

The air-lift pump is relatively costly because of its power unit. Depreciation and fixed operating charges are low, but the efficiency is also low, and because of the low efficiency this type of plant is not well adapted for pumping for irrigation except under special conditions, such, for instance, as a number of deep wells in close proximity to each other, all having sufficient depth of water to afford proper submergence.

OTHER TYPES.

The pumps already described are those chiefly used in irrigation from wells, and it is advisable to go slowly in the purchase of any new and untried type, no matter what the principle of operation may be. Improvements constantly are being made in pumping apparatus, but the advantages of innovations should be demonstrated and well understood before they are adopted.

SELECTION, INSTALLATION, AND OPERATION OF PUMPS.

Under ordinary circumstances the horizontal centrifugal type is best adapted to lifts of 50 feet or less. If electric power is not available, 40 feet is usually considered the maximum lift for the horizontal centrifugal. Lifts from 50 to 75 feet may be managed by vertical centrifugal or turbine pumps as particular conditions may direct. The turbine pump is best adapted to lifts from 75 to 150 feet. There is a range between 150 and 250 feet where selection is possible between turbine and plunger types, but the deep-well turbine centrifugal type is best for pumping large quantities of water within this range of lifts. The plunger pump is to be considered when the depth to the water is great and the quantity of water to be pumped is not more than 500 gallons per minute. The air lift is restricted neither as to lift nor quantity of water to be pumped, but its low efficiency should limit its use to the special conditions already mentioned.

All three types of centrifugal pumps should be ordered to fit given conditions of lift and capacity. Too often the only condition stipulated by the farmer ordering a horizontal or vertical centrifugal pump is that it discharge a specified quantity of water, but it should be remembered that it is possible to obtain widely varying quantities of water from a centrifugal or turbine pump by varying the speed of its operation. Hence an unscrupulous pump dealer can convey a false impression as to the capacity of a pump by forcing it to an uneconomical and inefficiant speed. There is only one set of conditions of discharge and speed under which centrifugal pumps will operate for a given head at maximum efficiency. A pump bought in ignorance of this fact, with cheapness as the main consideration, will prove more costly in the long run than the more expensive but efficient pump.

The approximate capacities and efficiencies of different sizes of centrifugal pumps (not including the turbine type) are given in Table 1. In ordinary practice a good pumping plant, properly installed, should easily reach the efficiency shown.

TABLE 1.—*Typical capacities of centrifugal pumps and horsepower required for their operation under average conditions.*[1]

No. of centrifugal pump.	Discharge per minute.	Theoretical horsepower per foot of lift.	Efficiency.	Actual horsepower per foot of lift.[2]	No. of centrifugal pump.	Discharge per minute.	Theoretical horsepower per foot of lift.	Efficiency.	Actual horsepower per foot of lift.[2]
	U. S. gals.		*Per cent.*			*U. S. gals.*		*Per cent.*	
2	100	0.025	40 to 45	0.06	5	700	0.175	62 to 66	0.28
2½	150	.038	45 to 50	.08	6	900	.225	66 to 68	.34
3	225	.056	50 to 55	.11	7	1,200	.300	68 to 70	.44
3½	300	.075	55 to 60	.14	8	1,600	.400	70 to 74	.57
4	400	.100	60 to 62	.17					

[1] Above efficiencies are for pumps properly designed and installed for heads of 40 to 60 feet. Plant efficiencies can be estimated by subtracting 10 per cent for direct-connected electric motors and 17 to 22 per cent for belt-connected power.

[2] Efficiencies taken as the lower in preceding column.

The amount of power lost in forcing a given quantity of water through a pipe varies with the length, size, and kind of pipe, the number and sharpness of bends, and the valves and other obstructions to flow. When a bend must be made in the discharge or suction pipe, a long-radius elbow should be used if possible. The suction pipe must be air-tight and should extend at least 20 feet below the level to which water will be drawn. The discharge pipe should be carried no higher than necessary, as each foot in height increases the cost of pumping.

Unlike centrifugal pumps, the discharge of the plunger pump can be varied by changing the speed without any sacrifice of efficiency. It should not, of course, be operated at a speed which will cause excessive wear. In order to reduce friction loss, suction and discharge pipes should be of sufficient size and have as few short bends as possible. This is likewise true of air-lift pumps. The discharge pipe or column of the air-lift pump should be large enough to keep the velocity of the water below 5 feet per second.

POWER UNIT.

Ample power must be available to operate a pumping plant without overloading the engine or motor. As a precaution the plant should be designed to meet a load 10 per cent greater than the estimated requirement. The power necessary to lift water is measured in horsepower. One theoretical horsepower represents the energy required to lift 33,000 pounds 1 foot high in 1 minute.

Table 2 shows the actual horsepower needed to lift different quantities of water to elevations of 10 to 300 feet, assuming the efficiency of the plant to be 50 per cent. Oil engines and motors usually are rated on brake horsepower. Engines and motors manufactured by reputable firms will deliver their rated horsepower, and in emergencies motors are generally good for a small overload for a short run; but it is never wise deliberately to overload either oil engines or motors, as difficulties in operation are almost certain to follow.

TABLE 2.—*Horsepower required to lift different quantities of water to elevations of 10 feet to 300 feet.*

[Efficiency of pumping plant, 50 per cent of theoretical. Use for estimating purposes only.]

Gallons per minute.	Cubic feet per second.	Elevation in feet.															
		10 h. p.	20 h. p.	30 h. p.	40 h. p.	50 h. p.	60 h. p.	70 h. p.	80 h. p.	90 h. p.	100 h. p.	125 h. p.	150 h. p.	175 h. p.	200 h. p.	250 h. p.	300 h. p.
250	0.56	1.25	2.50	3.75	5.00	6.25	7.50	8.75	10.00	11.25	12.50	15.62	18.75	21.88	25.00	31.25	37.50
300	.67	1.50	3.00	4.50	6.00	7.50	9.00	10.50	12.00	13.50	15.00	18.75	22.50	26.25	30.00	37.50	45.00
350	.78	1.75	3.50	5.25	7.00	8.75	10.50	12.25	14.00	15.75	17.50	21.88	26.25	30.62	35.00	43.75	52.50
400	.89	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	25.00	30.00	35.00	40.00	50.00	60.00
450	1.00	2.25	4.50	6.75	9.00	11.25	13.50	15.75	18.00	20.25	22.50	28.12	33.75	39.38	45.00	56.25	67.50
500	1.12	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00	31.25	37.50	43.75	50.00	62.50	75.00
600	1.34	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	27.00	30.00	37.50	45.00	52.50	60.00	75.00	90.00
700	1.56	3.50	7.00	10.50	14.00	17.50	21.00	24.50	28.00	31.50	35.00	43.75	52.50	61.25	70.00	87.50	105.00
800	1.78	4.00	8.00	12.00	16.00	20.00	24.00	28.00	32.00	36.00	40.00	50.00	60.00	70.00	80.00	100.00	120.00
900	2.01	4.50	9.00	13.50	18.00	22.50	27.00	31.50	36.00	40.50	45.00	56.25	67.50	78.75	90.00	112.50	135.00
1,000	2.23	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00	62.50	75.00	87.50	100.00	125.00	150.00
1,250	2.78	6.25	12.50	18.75	25.00	31.25	37.50	43.75	50.00	56.25	62.50	78.12	93.75	109.38	125.00	156.25	187.50
1,500	3.34	7.50	15.00	22.50	30.00	37.50	45.00	52.50	60.00	67.50	75.00	93.75	112.50	131.25	150.00	187.50	225.00

Lifts and quantities may be derived from the following formula:

$$\text{Horsepower} = \frac{\text{g. p. m.} \times h}{4{,}000 \times E}$$

Where *g. p. m.* = Gallons pumped per minute.
h = Total head in feet against which pump must work. This includes the total vertical lift, plus frictional and other losses.
E = The efficiency of the pump.

The horsepower in this instance is the power applied at the pump pulley. The efficiency usually specified by the pump manufacturer is the *E* used in this formula. It must be kept in mind that friction caused by the movement of the water in the suction and discharge pipes, and obstructions to the flow caused by bends, valves, etc., offer further resistance which must be overcome by the pump. These losses converted to feet of additional height through which the water must be lifted, are taken into account in the *h* in the above formula. In Table 2, the horsepower of the engine or motor specified is taken as twice the horsepower theoretically required, this being the usual practice with pump manufacturers. However, as indicated in Table 1, the value of *E* increases with the size of the pump.

THE ELECTRIC MOTOR

Where electric current is obtainable at reasonable cost, it is the most satisfactory source of power for irrigation pumping. Electric motors combine reasonably low cost, safety, high efficiency, reliability, and ease of operation.

The range of speed in the various sizes of electric motors is such that they are readily adapted to the operation of pumps. The electric motor, not requiring constant attention, may be direct connected to the pump shaft, so eliminating friction and slippage losses due to transmission through gears or belts.

Direct-connected electric plants are compact and require less housing than plants of other types, and avoid the trouble of purchasing, hauling, and storing fuel. The following rates are charged by a California company supplying current to many pumping plants. They give a fair idea of the cost of such service.

TABLE 3.—*Rates charged for electricity.*

Size of installation (horsepower).	Annual demand charge per horsepower.	Energy charge in addition to the demand charge; rate per kilowatt hour for consumption per horsepower per year of—			
		First 1,000 kilowatt hours.	Next 1,000 kilowatt hours.	Next 1,000 kilowatt hours.	All over 3,000 kilowatt hours.
	Dollars.	*Cents.*	*Cents.*	*Cent.*	*Cent.*
2 to 4	[1] 6.60	1.6	1.2	0.9	0.7
5 to 14	6.00	1.4	1.1	.8	.7
15 to 49	5.40	1.2	1.0	.8	.7
50 to 99	4.50	1.1	.9	.75	.7

[1] In no case will the total annual demand be less than $13.20.

Any consumer may select at his option the following rate instead of the demand and energy rate set forth above:

Horsepower of connected load.	Annual minimum charge per horsepower.	Rate per kilowatt hour for consumption per horsepower per year of—				
		First 300 kilowatt hours.	Next 700 kilowatt hours.	Next 1,000 kilowatt hours.	Next 1,000 kilowatt hours.	All over 3,000 kilowatt hours.
	Dollars.	*Cents.*	*Cents.*	*Cents.*	*Cent.*	*Cent.*
2 to 4	[1] 9.00	3.8	1.6	1.2	0.9	0.7
5 to 14	8.00	3.4	1.4	1.1	.8	.7
15 to 49	7.50	3.0	1.2	1.0	.8	.7
50 to 99	7.00	2.6	1.1	.9	.75	.7

[1] In no case will the total minimum charge be less than $27 per year.

Some companies supply current at flat monthly rates, and one such enterprise, to encourage continuous use of power, quoting its rates upon "the connected load in motors or other utilization equipment which can be connected at any one time to the company's supply system," allows the consumer to use electric energy, under certain conditions, for operating small motors to cut alfalfa or other feed, grind corn, operate cream separators, pump water for domestic purposes or for stock, or for like purposes.

Where electric power is to be utilized, frequently several miles of power line must be provided in order to tap the main line of some large power company, and secondary lines must be constructed to each pumping plant. The cost of these power lines, especially when they are long, is an important item in the cost of pumping plants. Ordinarily it is met at first by the consumer; but some companies divide it with their customers or refund it in service.

THE INTERNAL-COMBUSTION ENGINE.

Internal-combustion engines are efficient and with proper care will continue to be so through a comparatively long life. This is especially true of the Diesel and semi-Diesel types, which are ordinarily adapted, however, only to installations of large size. It is commonly regarded that an engine will last from 8 to 12 years. Some farmers pump water only a few days per week or only a few hours per day, others operate their plants continuously day and night, and the length of the irrigation season varies widely in different localities; hence the life of an engine used to operate a pumping plant can not be estimated closely in years. Its life in hours depends upon three factors: The quality of metal and workmanship put into its manufacture, the load it operates under, and the attention given to its operation, and the fuel used. The first factor is of interest to a purchaser, but internal-combustion engines usually are well built and are delivered in good condition.

A heavily loaded engine will not last as long as one lightly loaded, a load of 75 to 80 per cent of the rating of the engine usually being the safe maximum. A substantial foundation is necessary to reduce vibration; and the distance between, comparative elevations, and alignment of pump and engine pulleys should be such as to avoid belt trouble. Instructions regarding these matters are furnished by the pump or engine company from which the purchase is made. An engine should have a good sight-feed lubrication and an ample cooling system. Poor lubricating oil should not be used. Proper housing of an engine is important, particularly in a country where freezing weather or sandstorms occur. The housing should be as nearly dustproof as possible. Dust, dirt, grime, rain, and neglect cause rapid depreciation. Every engine should be cleaned at regular intervals, and bolts, springs, valves, and other parts should be examined and necessary repairs made.

Suitability of fuel is a big factor. One obstacle to the continued use of the internal-combustion engine for pumping in recent years has been the uncertainty about securing a supply of fuel oil at prices making its use practical, and it is well to select an engine which will run on more than a single grade of oil. An engine using the heavier grades of oil had best be chosen, since it will work with the lighter oils when the cheaper grades are not available. However, it is false economy, when proper oil is available, to try to burn cheap oils which are too heavy or contain too much asphalt.

Clean combustion is very important in prolonging the life of an engine. A smoky exhaust indicates a foul, dirty cylinder, injurious deposits, and rapid wear. Engine performance depends principally on the condition of cylinders and piston rings; other parts can be maintained in good order with occasional small expenditures.

Difference in atmospheric pressures causes a difference in power produced by engines, and although this is not large it should be taken into account where installations are made at considerable heights above sea level.

COST OF PUMPING INSTALLATION.

It is beyond the scope of this bulletin to give costs of pumping-plant installations in such detail that they will be generally applicable throughout the irrigated region. In order that the prospective purchaser may have clearly in mind the items which usually enter into the cost of pumping plants, estimates of the cost of plants of the three types in most common use are given. Conditions peculiar to different communities will qualify these estimates and the cost reported should be considered as suggestive only. Before a plant is purchased, quotations on the equipment it is proposed to install should be secured from reliable dealers. In each of the three types described the cost of the transmission line is omitted for reasons stated on page 22. The reader should ascertain what expense would be involved in bringing electrical current to his farm from the nearest power main and what refunds would be made in case the initial expense were charged to him, amending this estimate accordingly.

CASE NO. 1.

Electrically-driven centrifugal pump in pit. (See fig. 3.)

Conditions:
- Crop to be irrigated, alfalfa.
- Depth of water required on land, 3 feet in six irrigations, in a 30-day rotation in 6-inch applications.
- Amount of water furnished by well, 2 second-feet=900 gallons per minute, which will irrigate 4 acres 6 inches deep each 12 hours or 120 acres in thirty 12-hour days or fifteen 24-hour days.
- Lift of water=40 feet.
- Theoretical horsepower, 9.
- Plant efficiency, 60 per cent.
- Motor required, 15 h. p.

Cost of plant:		
Well 100 feet deep, drilling at $2 per foot	$200.00	
Casing, 12-inch double stovepipe, 12 gauge, 60 feet, at $2.25	135.00	
Casing starter 20-foot, 3-ply, and ring	90.00	
Pit, 8 by 8 by 25 feet inside; concrete 6-inch walls and bottom, at $15 per foot depth	375.00	
Total		$800.00
Pump No. 6 single stage horizontal centrifugal, direct-connected to 15 horsepower electric motor, installed with necessary electric and hydraulic accessories	900.00	
Pump house with overhead lifting device, concrete floor, pit railing, etc	400.00	
Total		1,300.00
Total cost of plant		2,100.00
Cost per acre ($1,200÷120)		17.50
Cost of operation per season:		
Interest on $2,100 at 7 per cent	147.00	
Taxes and insurance at 1 per cent	21.00	
Depreciation of machinery (value $900) at 10 per cent	90.00	
Depreciation of house and well (value $1.200 at 5 per cent	60.00	
Power consumed, 11.2 kilowatts for 2,160 hours at 2 cents per kilowatt hour	483.84	
Repairs, lubricating oil and attendance, per season	50.00	
Total cost of operating per season		851.84
Cost of pumping per acre season ($851.84÷120)		7.10
Cost of pumping per acre-foot of water ($7.10÷3)		2.37

Centrifugal pump in pit, driven by oil engine.

It is estimated that the plant described in Case 1 could be installed with a 15-horsepower oil engine, necessary changes being made in pit and house design, at an approximate cost of		$2,800.00
Cost per acre for oil engine plant ($2,800÷120)		23.33

Cost of operating with oil engine.

Interest on $2,800 at 7 per cent	$196.00	
Taxes and insurance at 1 per cent	28.00	
Depreciation of machinery (value $1,600) at 10 per cent	160.00	
Depreciation of house, well and pit (value $1,200) at 5 per cent	60.00	
Fuel consumed 1⅓ gallons 24-gravity oil per hour for 2,160 hours, at 5 cents per gallon	162.00	
Repairs, lubricating oil, and attendance per season	150.00	
Total cost of operating per season		$756.00
Cost of pumping per acre per season ($756÷120)		6.30
Cost of pumping per acre-foot of water ($6.30÷3)		2.10

CASE No. 2.

Electrically-driven, deep-well turbine pump. (See fig. 2.)

Conditions:

- Crop to be irrigated, fruit.
- Depth of water required on land, 1.5 feet in three irrigations, in a 60-day rotation of 6-inch applications.
- Amount of water furnished by well, 1 second-foot=450 gallons per minute, which will irrigate 2 acres 6 inches deep each 12 hours or 120 acres in sixty 12-hour days.
- Lift, 100 feet.
- Theoretical horsepower, 11.25.
- Plant efficiency, 50 per cent.
- Motor required, 25 horsepower.

Cost of plant:		
Well 200 feet deep, drilling at $2 per foot	$400.00	
Casing, 12-inch double stovepipe, 12 gauge, 180 feet at $2.25	405.00	
Casing starter 20-feet, 3-ply, and ring	90.00	
Cost of well, total		$895.00
Pump, deep-well turbine installed on concrete base with direct-connected vertical 25-h. p. motor	1,500.00	
Electric protection accessories	200.00	
Pump house, 8 by 8 by 7 feet posts	100.00	
Cost of pumping plant installed, total		1,800.00
Total cost of plant		2,695.00
Cost of plant per acre ($2,695÷120)		22.46
Cost of operation per season:		
Interest on $2,695 at 7 per cent	188.65	
Taxes and insurance on $2,695 at 1 per cent	26.95	
Depreciation of machinery (value $1,700) at 10 per cent	170.00	
Depreciation of well and building (value $995) at 5 per cent	49.75	
Power consumed, 16,785 kilowatts for 2,160 hours at 2 cents per kilowatt hour)	725.11	
Repairs, lubricating oil, and attendance per season	100.00	
Total cost of operation per season		1,260.46
Cost of pumping per acre per season ($1,260.46÷120)		10.50
Cost of pumping per acre-foot of water ($10.50÷1.5)		7.00

Deep-well turbine pump driven by oil engine.

It is estimated that the plant described in Case 2 could be installed with a 25-horsepower oil engine, enlarged pump house, and foundation for approximately		$3,700.00
Cost per acre of oil-engine plant ($3,700÷120)		30.83

Cost of operating per season with oil engine.

Interest on $3,700 at 7 per cent	$259.00	
Taxes and insurance on $3,700 at 1 per cent	37.00	
Depreciation of machinery (value $2,600) at 10 per cent	260.00	
Depreciation of well, pump house, etc. (value $1,100) at 5 per cent	55.00	
Fuel consumed, 2½ gallons per hour for 2,160 hours, at 5 cents per gallon	270.00	
Repairs, lubricating oil, and attendance per season	300.00	
Total cost of operating per season		$1,181.00
Cost of pumping per acre per season ($1,181÷120)		9.84
Cost of pumping per acre-foot of water ($9.84÷1.5)		6.56

CASE NO. 3.

Electrically-driven deep-well plunger pump. (See fig. 4.)

Conditions:

- Crop to be irrigated, apples or citrus orchards.
- Depth of water required on land, 1.5 feet in three irrigations, in a 60-day rotation of 6-inch applications.
- Amount of water furnished by well, one-half second-foot=225 gallons per minute, which will irrigate 1 acre 6 inches deep each 12 hours, or 60 acres in sixty 12-hour days.
- Lift, 200 feet.
- Theoretical horsepower, 11.2.
- Plant efficiency, 70 per cent.
- Motor required, 20 horsepower.

Cost of plant:

Well 300 feet deep, drilling at $2 per foot	$600.00	
Casing, 12-inch double stovepipe, 12 gauge, 280 feet at $2.25 per foot	630.00	
Casing starter, 20 feet, 3-ply, and ring	90.00	
Total cost of well		$1,320.00
Pump, double-acting, deep-well, working head on slide rails, connected to 20-horsepower electric motor by short belt and idler or silent chain, 8-inch cylinder, 195 feet of column pipe, and double plunger rods, complete	$2,300.00	
Motor, 20 h. p., with protection accessories	550.00	
Derrick, with windlass and pump house	400.00	
Installation, labor, concrete foundation, freight, etc	650.00	
Cost of pumping plant installed		3,900.00
Total cost of plant		5,220.00
Cost of plant per acre ($5,220÷60)		87.00

Cost of operation:

Interest on $5,220 at 7 per cent	$365.40	
Taxes and insurance at 1 per cent	52.20	
Depreciation of machinery (value $3,500) at 10 per cent	350.00	
Depreciation of well and pump house (value $1,720) at 5 per cent	86.00	
Power consumed, 12.1 k. w. 2,160 hours at 2 cents per k. w. hour	522.72	
Repairs, lubricating oil, and attendance per season	100.00	
Total cost of operating per season		1,476.32
Cost of pumping per acre per season ($1,476.32÷60)		24.61
Cost of pumping per acre foot of water ($24.61÷1.5)		16.41

Deep-well plunger pump, driven by oil engine.

It is estimated that the plant described in Case 3 could be installed with a 20-horsepower oil engine, an enlarged pump house, belt, and foundation for approximately	$5,900.00
Cost per acre of oil engine plant ($5,900÷60)	98.33

Cost of operating with oil engine.

Interest on $5,900 at 7 per cent	$413.00	
Taxes and insurance on $5,900 at 1 per cent	59.00	
Depreciation of machinery (value $4,080) at 10 per cent	408.00	
Depreciation of well, building, etc. (value $1,820), at 5 per cent	91.00	
Fuel consumed, 2 gallons per hour for 2,160 hours at 5 cents per gallon	216.00	
Repairs, lubricating oil, and attendance per season	250.00	
Total cost of operating per season		$1,437.00
Cost of pumping per acre per season ($1,437÷60)		23.95
Cost of pumping per acre foot of water ($23.95÷1.5)		15.97

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March 22, 1924.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1405

The WINDBREAK AS A FARM ASSET

WINDBREAKS are, in more ways than one, a farm asset. They tend to prevent the soil from drying out quickly and they protect grain and orchards from mechanical injury by the wind. A belt of trees by the farm buildings protects them from extreme winter cold and summer heat, and makes the farm a pleasanter place in which to live. The windbreak may also be a source of wood supply for use on the farm or for sale. This bulletin tells how windbreaks act and what returns may be expected from them in dollars and cents.

This bulletin is a revision of and supersedes Farmers' Bulletin 788.

Washington, D.C. Issued January, 1924

THE WINDBREAK AS A FARM ASSET.

By Carlos G. Bates, *Forest Examiner, Forest Service.*

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WINDBREAKS ON THE PRAIRIES.

When the prairie regions of the Middle West[1] were first developed the lack of trees was felt severely. The clear sweep of the winds across the flat plains was a great hindrance to agriculture, for the soil was dried out quickly by evaporation, and grain was lodged and orchards injured by the mechanical force of the wind. Windbreaks were the only remedy, and thousands of miles of them were planted along roads and farm division lines. The effect of this planting, though only gradually felt, was very distinct; farming and living conditions became more favorable throughout the whole region.

Considerable planting is still being done, but probably no more than enough to counterbalance the cutting in windbreaks already planted. Of course the need of windbreaks is not so acute now as it has been in the past, but some extension of the planting in this region is desirable, at least enough to protect the new areas which have been put under cultivation.

WHAT IS A WINDBREAK?

Any body of trees which gives protection to buildings or crops may be called a windbreak. This bulletin has to do, however, only with belts of trees planted about fields and farm buildings, especially for the purpose of breaking the force of the wind. The typical windbreak is a belt consisting of from six to eight rows of trees and usually from a quarter of a mile to a mile in length.

HOW A WINDBREAK PROTECTS.

CHECKING WIND MOVEMENT.

The influence of a timber windbreak upon air currents is purely mechanical. Its effectiveness depends, therefore, upon how nearly impenetrable it is. The ordinary windbreak does not provide an absolute barrier to the wind; a certain amount of air forces its way between the branches and foliage of the trees, so that the movement of the air on the leeward side is not completely stopped but only greatly reduced. When windbreaks composed of such trees as cottonwood become old, wide openings are left between the bare trunks and more wind gets through near the ground than higher up.[1] Such windbreaks can be made efficient only by underplanting the cottonwood with other trees or shrubs.

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[1] The Middle West includes the States of Illinois, Iowa, Minnesota, Dakota, Nebraska, and Kansas.

An ideal windbreak for checking wind currents would have the contour of an earth dam. In the central rows would be planted the tallest trees, such as cottonwood; on either side, rows of shorter trees, such as ash and locust; and outside of these, low bushes or cedars. Such a windbreak would not be easily penetrated, and its inclined surface would divert the air currents upward and relieve the horizontal wind pressure.

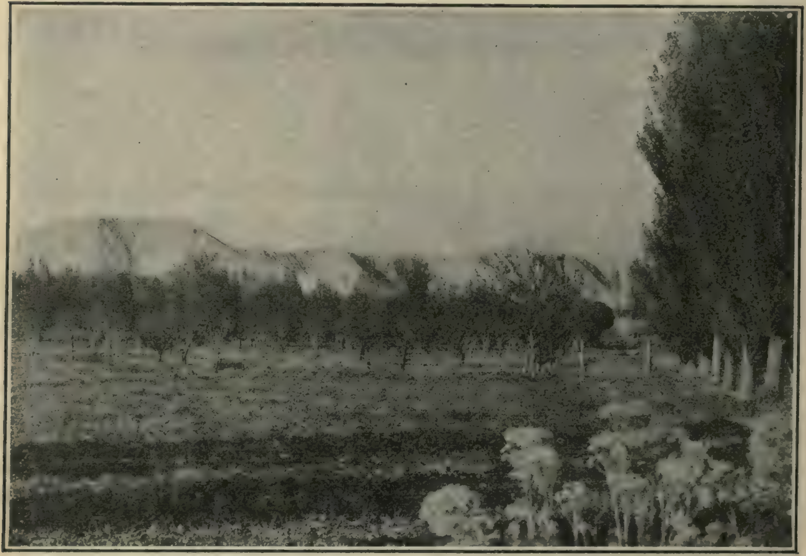

FIG. 1.—On irrigated lands in western Colorado (Mesa County), the Lombardy poplar, a close relative of the cottonwood, grows thriftily, and is used for the protection of orchards.

Breaking the mechanical force of the wind benefits the farmer most directly by protecting his grain crops and his orchard. The value of the windbreak in giving this protection is, of course, difficult to measure in dollars and cents, but where winds are at all frequent such protection alone may be equal to the rental of the ground occupied by the trees. In one case in southern Minnesota a windbreak,

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[1] A dense mulberry hedge of a single row may offer quite as much resistance to the wind near the ground as several rows of open-growing locust or cottonwood.

80 rods long and about 28 feet high along the side of a cornfield, afforded complete protection for a strip about 10 rods wide during a wind blowing at 50 miles an hour. On the unprotected part of the field the wind blew down half the corn and bent the remainder halfway, the damage beginning at the edge of the 10-rod strip and increasing until it was greatest in that part of the field farthest from the windbreak. The corn was in the milk stage at the time of the high wind and did not produce more than a third of a crop on the damaged area. On the protected portion the total saving was 260 bushels, or the full crop of 6 acres, whereas the windbreak occupied only 2 acres.

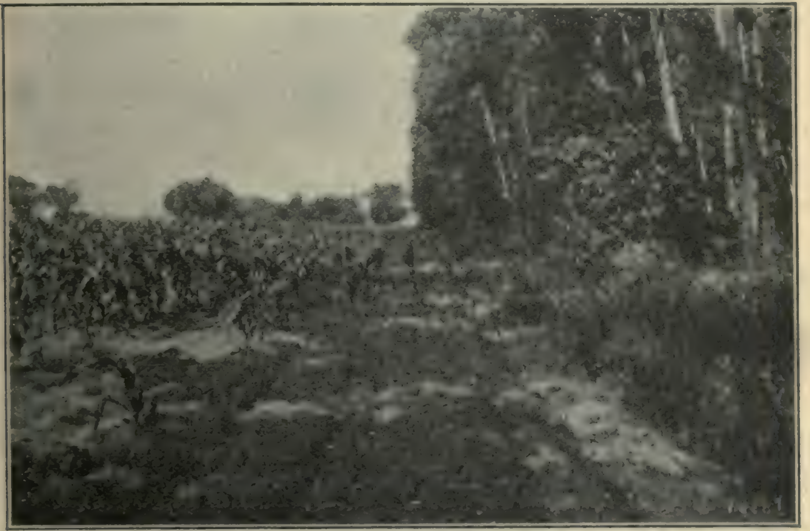

FIG. 2.—Corn to the north of a cottonwood grove is badly damaged by shade in a few rows adjacent to the trees.

Movement of the topsoil also may be checked and dust storms prevented by breaking the force of the wind. For this reason windbreaks are of immense benefit in sandy regions or regions where the soil is very fine.

Added to the crop and soil protection there is the personal comfort to be derived from protection from wind about the farm and home and along public roads. Furthermore, a protected home is heated in winter more readily, and hence more cheaply, than one exposed to the wind.

REDUCING EVAPORATION.

There is no part of the United States, except small areas in the Appalachian and Cascade Mountains, which normally obtains more precipitation than is needed for growing the best crops. The farmer usually plows, cultivates, and mulches with the object of conserving every drop of water that may reach the soil during the year. In the "dry-farming" regions of the West these conservation measures are carried farthest. Here it may be necessary to save the moisture of two seasons to grow a single crop.

Anything which helps to conserve the moisture of the soil is of direct benefit to the farmer. The windbreak has this effect in a marked degree. The drying power of the wind is reduced by the windbreak very nearly in the same proportion as its velocity. In the immediate lee of the most effective windbreaks evaporation is reduced as much as 65 per cent. Farther from the trees the reduction is less. The amount of reduction depends not only upon the density and proximity of the windbreak, but upon whether the field is fallow or in crops. The saving in moisture is least when the field is fallow, so that the only reduction is in the direct evaporation from the soil; it is greatest when the field is in crops, so that there is a reduction not only in the direct evaporation from the soil but also in the evaporation from the leaves of the crops.

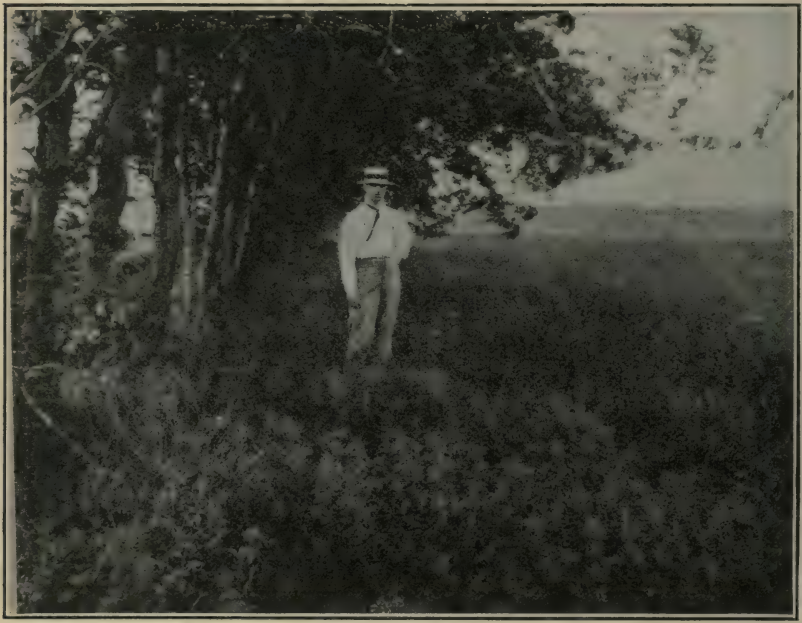

FIG. 3.—Alfalfa grows almost to the base of honey-locust trees.

The more frequently winds occur in any locality during the growing season, and the greater their velocity and drying power, the more important it is to use every means of preventing evaporation. Windbreaks are especially valuable, therefore, in the Middle West, where hot, dry winds, often of high velocity, are of frequent occurrence during the summer months, and in Montana and the Dakotas, where the warm west winds of the winter and early spring, known as "chinooks," do great damage to winter wheat and orchards.

EFFECT ON TEMPERATURE.

The farmer who has cultivated crops on a hot summer day need hardly be told that the warmest part of his field is the portion which is sheltered from the wind. In the lee of the windbreak there is not only no breeze to cool the body and reduce what is known as the "sensible temperature," but the actual temperature of the air is raised. Tests with a thermometer have shown that the area which is protected by a windbreak may be several degrees warmer during the day and several degrees cooler during the night than adjacent areas not protected.

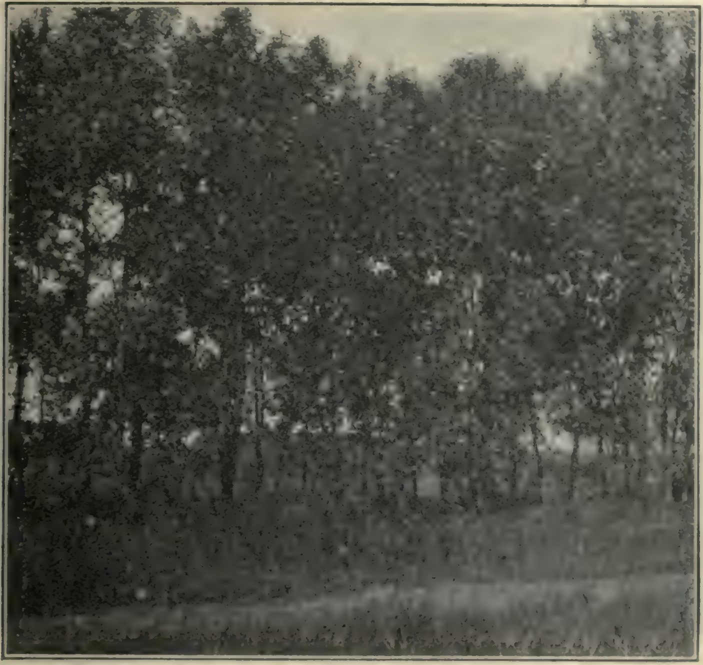

FIG. 4.—The branches of ash are small and short, and the tree does little damage by shading crops.

Such crops as corn are benefited very greatly by warm, sultry days. The windbreak helps to create these conditions and offsets to some extent the effect of cold, cloudy weather. The cooling effect at night is of course unfavorable to growth then; but the night is a period of comparative rest, so that the nocturnal cooling off is far more than counterbalanced by the higher temperatures secured during the day.

Windbreaks may appear undesirable for the protection of orchards in blossom or garden crops which are not hardy, because the danger of still frost seems increased by the stagnation of the air on the lee side. The added danger is more apparent than real, however, for still frosts only occur when there is practically no wind, and a windbreak can then have little effect one way or the other. Furthermore, complete stagnation of the air may be helpful rather than harmful if smudging is resorted to.

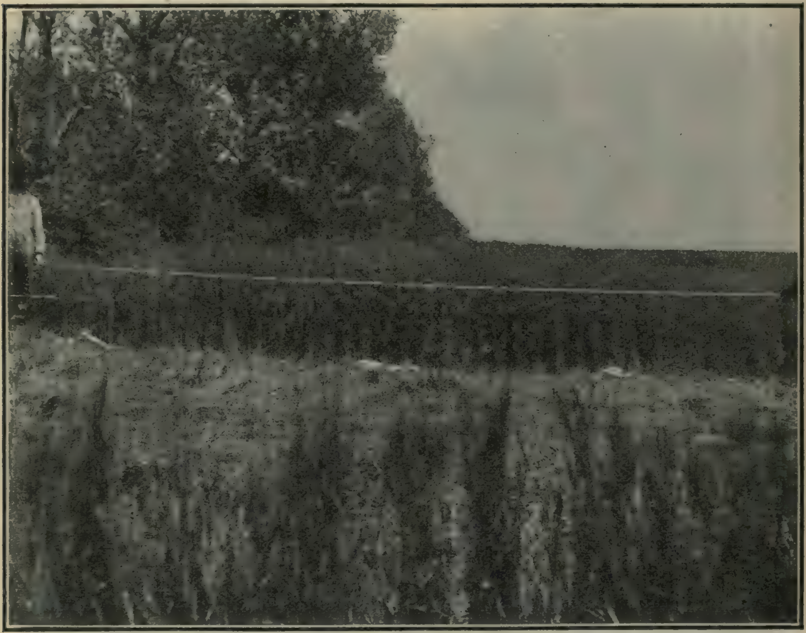

Fig. 5.—Wheat near the trees has been benefited by the covering afforded where snow drifted in the lee of the windbreak.

The freezing which often causes the most severe damage to orchards is that which follows a cold rain or late snow. During such a freeze the damage to blossoms is greatly reduced by protection from wind; for evaporation which produces a rapid cooling increases in proportion to wind velocity. During a freeze of this kind in Nebraska in 1908, fully protected orchards yielded crops many times as heavy as those without exterior protection, and even the leeward side of individual trees exposed to the wind suffered much less damage than the windward side. It is noteworthy also that the one storm of rain and snow, with a temperature of 28 degrees, did all the damage during the season, and that later frosts with lower temperatures did not affect the orchards.

EFFECT OF THE WINDBREAK ON YIELD OF CROPS.

The effect of a windbreak on crops is not beneficial in every respect. There are certain ways in which it is plainly injurious. Trees in a windbreak always spread their roots extensively into the adjoining fields in search of moisture; and they take not only the moisture but some of the nitrogen content of the soil. Furthermore, by shading the ground they may prevent crops from developing properly.[1]

Whether the total effect of a windbreak is good or bad depends upon whether the benefits derived from its influence on wind movement, temperature, and evaporation are greater or less than the injury resulting from the sapping and shading of the ground near by.

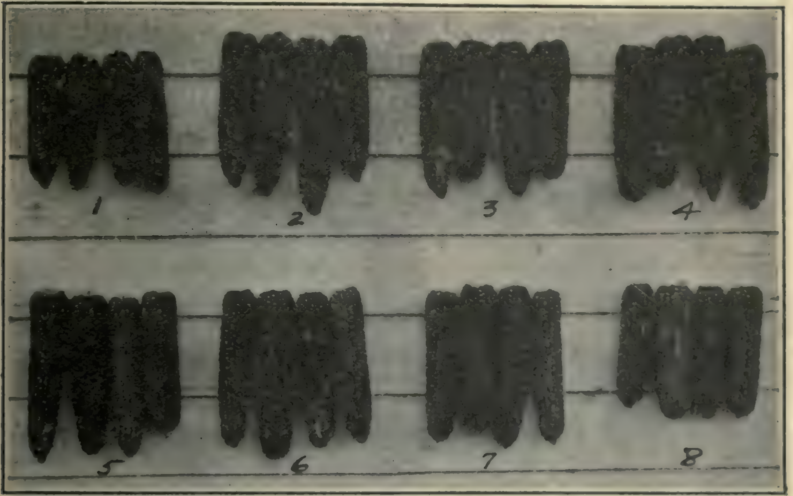

FIG. 6.—Effect of windbreak protection on quality of corn. *1*, In rows shaded by trees; *2–7*, average maximum ears from protected rows; *8*, ears from unprotected portion of field.

To determine the total effect, crop measurements have been made in Nebraska, Kansas, Iowa, and Minnesota. Average rather than exceptional conditions were measured, the object being to discover the effect of those influences which are continuous and affect every annual crop grown.

Measurements made in fields of small grain indicate that the crop gain in the protected zone is sufficient to offset fully the effects of shading and sapping. In a wheat field protected by a dense windbreak the gain amounted to about 10 bushels per acre where the protection was most complete, and gradually grew less as the distance from the windbreak increased. The total gain was about equal to the amount of grain which could have been grown on the shaded ground near the trees. The season in which the measurements were taken was not of high winds, nor did it lack moisture. It would appear, therefore, that in a windy year when evaporation was high the total gain for the field would much more than balance the loss. In another case, barley on the south of an ash and honey locust windbreak benefited very materially from the accumulation of snow in the lee, and the conservation of this moisture. Here cultivation was possible within 4 feet of the stems of the trees, so that the increased yield of the field, amounting to about 14 bushels per acre at the highest point, was practically clear gain. The total gain for the whole field amounted to the yield of a strip of ground as long as the windbreak, and three times as wide as its height. In other words, had the windbreak, which was 20 feet high, occupied a strip of ground 60 feet wide, the gain in the field crop would have paid the rental on all of this ground.

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[1] Some crops do better than others when shaded. Seeding crops, such as timothy and alfalfa, are least affected; grains which develop early in the spring, such as oats and wheat, are most affected, and corn occupies an intermediate position.

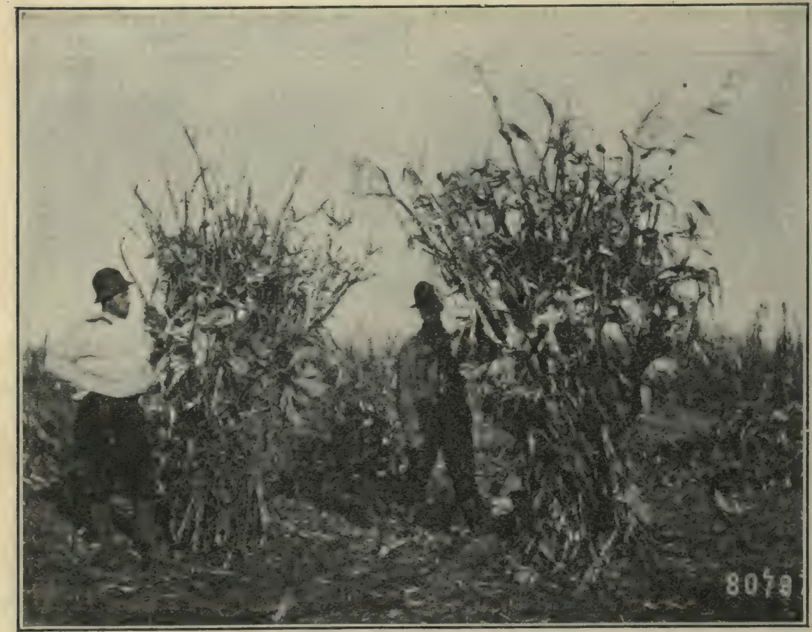

FIG. 7.—Effect of favorable atmospheric conditions on growth of corn plants and yield of fodder. On right, in protected zone (weight, 81 pounds); on left, in unprotected zone (weight, 42 pounds).

The corn crops showed more consistent and marked benefits from protection than any others. In the region concerned the summer winds are almost wholly from the south, so that the only effective rows and belts extended in an east-west direction. The effect on corn was very marked for a short distance on the south side of such windbreaks and for a much greater distance on the north side. Fields of young corn showed much better growth in the area protected and warmed by the windbreak. The effect was visible to the eye early in the season, which was rather cool. Height measurements on one field showed the plants to be 4½ feet high in the first 18 rows next to the windbreak, while beyond this protected zone the height was only 2½ feet. This luxuriant growth was still in evidence at the end of the season, and not only produced more fodder, but bigger and heavier ears. The field showed a production of 59 bushels to the acre in the protected part and only 41 bushels in the exposed part. The net gain, including the area shaded by the grove, was equivalent to the yield of a strip twice as wide as the height of the trees, which were 38 feet high. The increased yield paid, then, for a strip 76 feet wide. The windbreak happened to be wider than this, but need not have been to afford the same amount of protection.

With ordinary field crops the farmer may count on a benefit from windbreak protection which will make the loss of the area occupied by the trees negligible. Under Middle Western conditions a windbreak whose width does not exceed two or three times its height will more than pay for itself, regardless of the timber which it may produce. Farther east the same kind of influence and benefit will exist, though in a less marked degree, and a greater direct return may be expected from growing the timber for its own value, so that the need of even a slight amount of protection should make windbreak planting attractive.

WHERE AND WHAT TO PLANT.

In any region the windbreak should be so laid out as to offer the greatest resistance to damaging winds and to protect the greatest area. This simply means having the belt or row at right angles to the prevailing winds.

In most of the Middle West the principal wind to be feared is the drying south wind of summer. Where the soil is reasonably moist, the cottonwood belt, extending east and west across the southern boundary of the farm, is preeminently the windbreak for this region. It may be supplemented by other east-west windbreaks or hedges, dividing the farm into lots and fields, and made up of mulberry or osage orange, green ash, or locust, depending upon the moisture of the soil. The cottonwood windbreak is recommended because it so quickly attains great height and produces so much wood for fuel. After it has grown, however, it may need underplanting or side planting to fill the gaps in the lower story. The underplanting, if any, must be done within a few years after the planting of the cottonwood. For this purpose green ash or red oak is recommended. On the drier situations the main planting must be done with some of the more drought-resistant species which do not attain such great height. Green ash or locust for the main belt and osage orange for the hedge can not be excelled.

In the western part of this region more attention may have to be given to westerly winds, and the direction of the rows changed. In eastern Colorado, for instance, the windbreak must be planted so as to afford protection from the spring winds from the west, which are often very damaging.

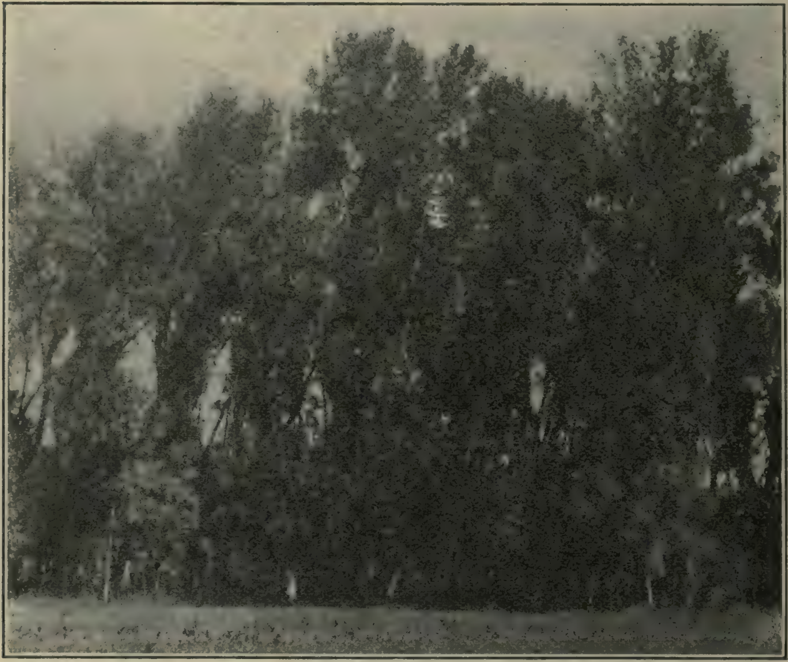

FIG. 8.—When mature, cottonwood must be underplanted if the belt is to retain its efficiency.

On the northern prairies (western Minnesota and the Dakotas) southerly summer winds are not so much felt as the westerlies. Here windbreaks should be mainly north-south ones, although some protection on both the north and the south sides of the farm may be needed. Scotch and Norway pines, Colorado blue spruce, and Black Hills spruce are recommended where moisture is sufficient for them, because they give so much better winter protection than the hardwoods. On drier situations western yellow pine may be substituted for the Norway.

In the Lake States practically all damaging winds are from the west, although the orchard may need just as much protection from the easterly winds which usually precede and accompany a storm. White pine is recommended above all other species, because of its rapid growth and high timber value, which justify its planting in wide belts or groves. The planting of white cedar along the edges of older white-pine belts will greatly increase the efficiency of the existing windbreak. On the poorer soils Norway or Scotch pines may be used instead of white pine.

In the Eastern States the situation is essentially the same as in the Lake States. White pine may be generally used, and white and Norway spruces and white cedar may be used in mixture or to strengthen the older windbreak on the sides.

In the Southwest the choice of species is very limited, and in typically dry situations possibly nothing can be made to succeed which has greater value than sagebrush in the form of hedges placed at frequent intervals. With a little more moisture the native evergreens, piñon, alligator juniper, and cedars may be made to grow. With irrigation the species used in the Middle West can undoubtedly be utilized to good advantage. If possible, the windbreaks should extend northwest-southeast.

In California citrus orchards and other valuable crops need protection on all sides. Protection from the northerly "Santa Ana" is probably most essential to grains and other field crops. For all of these purposes Monterey cypress, Monterey pine, and eucalypts have proved very valuable.

In the Columbia River region of the Northwest, Carolina and Lombardy poplars and cottonwood are very efficient for the protection of orchards and crops against the mountain winds, usually of easterly origin. Even small willows have been used to good advantage in checking the drifting of sand.

GROUND SPACE NECESSARY.

The belt of trees forming a windbreak needs the use of a certain amount of ground beyond that on which it actually stands. There must be space for the roots to spread out in search of soil nourishment and moisture. It should be remembered that the row of trees is a productive agent quite as much as a row of corn and may need just as much growing space in proportion to its height. Some species of trees, of course, spread their roots wider than others and need more space. Of those commonly planted, mulberry, honey locust, and osage orange spread the farthest in proportion to their height, and green ash spreads the least. Cottonwood does not spread its roots so far as is generally supposed.

Cultivation tends to limit the spread of the roots by making more moisture available near the trees, though deep plowing or cutting the roots restricts the root extension at the expense of the growth of the trees themselves. On the other hand, competition between trees, where several rows are planted together, tends to make those on the outside of the belt push their roots farther out into the open ground.

The width of the strip of ground to be allowed the windbreak may be figured at from one and one-fourth to twice the height of the trees; for instance, a single row of trees 50 feet high should be allowed a strip of ground from 62 to 100 feet wide.

DIRECT RETURNS FROM PLANTING.

In addition to affording protection to crops and buildings, the windbreak usually has considerable value as a source of wood supply for use on the farm or for sale. In the following estimates of the timber value of various kinds of windbreaks the acreage on which the figures are based includes not only the ground actually occupied by the trees but also that which is shaded and sapped. The estimates are for annual yields per acre for the average number of years required to mature each species.

Cottonwood rows and narrow belts, planted on fairly moist bottom lands, yield from 60 to over 200 cubic feet of wood per acre-year, a fair average being about 130 cubic feet. This means nearly 1½ cords of fuel per year, but the greatest profit usually results from cutting at the age of about 40 years, when 75 per cent of the entire volume will make lumber. Figuring 5 board feet to each cubic foot, there should then be available, for each year of growth, about 480 board feet, besides one-third of a cord of fuel.

Willows, on thoroughly moist soils, also produce very large yields, but because they do not usually grow to large size their product is best computed as fence posts, some species of willow making fairly durable posts. Average figures for rows and small groves show a production of about 210 fence posts per acre per year, of which 60 per cent, or about 125 posts, will be first and second class posts, the remainder suitable for stays. In terms of fuel, the yield of willow plantations is about 1½ cords per acre, allowance being made in all these calculations for the large area occupied by the roots. Usually willow plantations will have reached their best at the age of about 10 years.

Green ash, which will grow on the driest situations within the region here discussed, gives much smaller yields than cottonwood or willow, even on the best soils, but its product is very useful on the farm and must be rated very high among the timbers that can be grown in a semiarid region. About 80 fence posts per year is an average yield, 50 per cent of these being firsts and seconds. At least 25 years are required with this species for the best development and returns.

Silver maple, though a fairly rapid grower, has very low value for any purpose and is practically of no value for fence posts. An average yield of one cord of fuel per acre-year may be expected when this species is planted on good agricultural land.

Honey locust will produce valuable fence material even when grown on dry ground, but does its best on deep, moist soil. On the best soils the yields at first are comparatively low, averaging only about 60 fence posts per year; and on dry soils the yields are proportionately less. Honey locust attains its greatest value if cut fairly young and allowed to sprout, the sprouts being very vigorous, and making posts of better average quality than the slow-growing first growth. Such sprouts will give a high yield in 10 or 12 years.

Osage orange is one of the best producers of fence material in the southern part of the plains region and makes an impenetrable hedge while growing. It does not require very much moisture. An average yield of about 90 posts per year may be expected from the acreage occupied by osage orange hedges, 35 per cent of these being firsts and seconds, and even the smaller ones having a good market value because of their durability.

Russian mulberry is another valuable hedge and producer of fence posts when planted on moist sandy land, its yields being among the highest and the product one of good quality. An acre planted to this species may be expected to yield 200 fence posts each year, the crop becoming available after 10 or 12 years.

White pine on soils of good quality and Scotch pine on more sandy soils may be expected to give high and constant yields, at least in northern Iowa, Minnesota, and the States farther east. Because their products are more for the market than for farm use, and because they require a relatively long period to mature, say 40 years, they are likely to make less appeal for windbreak planting than the quick-maturing hardwoods. But these pines give exactly what is needed in the northern region, which is winter protection, and because of this their final high market value should be carefully considered. Either species under favorable conditions is capable of producing 200 cubic feet of wood per acre per year, and an average of 150 cubic feet is not too high for their yield on agricultural lands. This, expressed in board feet, means at the end of 40 years 30,000 feet of lumber per acre, which at present stumpage prices should yield a handsome profit over the cost of planting and care.

Information concerning yields, crop benefits, and other aspects of planting is given in much greater detail in Forest Service Bulletin 89.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

January 22, 1924.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1406

Garden Irises

Iris ſusiana Maior
After de Bry
1640.

THE HISTORY of floriculture shows that some flowers more than others receive the attention of both professional and amateur gardeners, and of these a few have been developed and perfected to such degrees of refinement that they have become the objects of collective search.

The excesses of the one-time tulip mania probably will never be repeated; but there are to-day several flowers which are in great popular favor, with notable collections, both small and large, and with great centers of activity in the gardens of hybridists in this country and in Europe. The wealth of the ages is available for our gardens, and there is no treasury richer than that of the iris.

Washington, D. C. Issued January, 1926

GARDEN IRISES

By B. Y. Morrison, *Horticulturist, Office of Horticultural Investigations, Bureau of Plant Industry*

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THE APPEAL OF THE IRIS

IN THE GARDEN of the busy man or woman there should be no plants which require undue care or attention. This is especially true of the flower garden on a farm, where labor is spent of necessity upon the vital activities of the farm business and where it is the exception rather than the rule to find any individual with leisure enough to tend an elaborate flower garden.

If the farmer has a garden where he grows flowers other than shrubs, which make the largest show for a minimum of care, there is no candidate more worthy than the iris. It is to be had in a variety of colors and forms equaled by few hardy plants, is tolerant of many adverse conditions, is subject to attacks from few diseases and insects, and is relatively permanent. To be sure, it is not possible to have identical collections in Minnesota and Florida, in California and Massachusetts, but there are desirable species and varieties deserving the attention of each grower, who can often modify conditions to include a wider range than would at first appear possible.

DISTRIBUTION

The iris as a genus is confined to the Northern Hemisphere and completely encircles the globe. Its members are found from the edge of the arctic regions down to the shores of the Gulf of Mexico and of the Mediterranean. There are varieties which grow in bogs that are perpetually bogs, others that revel in bogs that afterwards become burning wastes, varieties that grow along the edges of the desert, others that grow in countries with marked dry seasons, and a great many that flourish with average conditions of climate and soil.

From the study of the geographical distribution of the iris, it appears that the two centers of original location are central and southern Europe and the Orient, especially China. For the most part, however, the exotic species are thoroughly at home on the American continent and in certain sections have established themselves as freely as any native plant.

SURVEY OF BOTANICAL TYPES

BEARDLESS IRISES

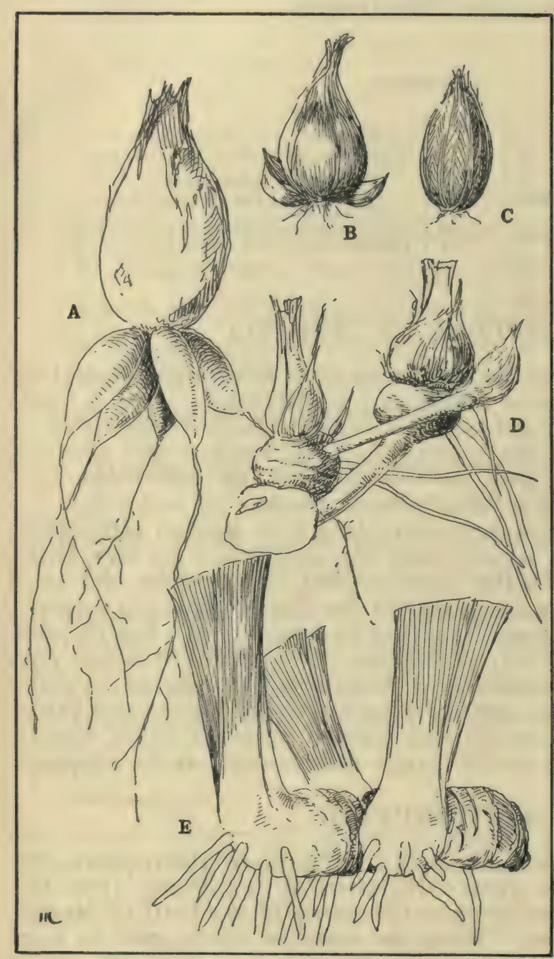

FIG. 1.—Types of iris roots: A, Bulb of an iris of the Juno group; B, bulb of an iris of the Xiphium group; C, bulb of an iris of the Reticulata group; D, rhizome of an iris of the Regelia group; E, rhizome of an iris of the Pogoniris group

As might be expected in a plant which has so wide a geographical range through such varying climatic conditions, there are many different forms of irises, and these are used by the botanists in arranging the species in their natural groups. Some members of these groups are not available or desirable for garden purposes, and they are purposely omitted from the brief presentation that follows.

The first characteristic which makes a distinct division among the wild irises of the world is the nature of the plant, some being furnished with rhizomes and others with bulbs. (Fig. 1.) The plants which have rhizomes are easily grouped by certain structural characteristics of the flowers and of the rhizome. The garden irises which have bulbs are in turn separated into two groups by the nature of the roots which come from the bulb—simple roots in one case and enlarged fleshy roots of more than annual duration in the other.

For the gardener the two most important groups of the rhizomatous form are those known as the apogons, or beardless irises, and the pogons, or bearded irises.

The first group is a very large one and contains many diverse forms. The most common garden examples are the Siberian and Japanese irises. All of these irises object to lime, and nearly all prefer moist rather than dry situations. Special requirements are noted in the several descriptions.

The Siberian iris (*Iris sibirica* L.) is the most important member of a group of small-flowered oriental species which are entirely hardy and of great value to the gardener. (Fig. 2.) The plant grows from a slender rhizome, which divides, forming compact clumps producing dense tufts of slender grasslike foliage from 10 inches to several feet high. The light-green foliage is lax and graceful, making a nice appearance in the border even when there are no blooms. The flowers are borne on very tall slender stems, ranging from 3 to 4 feet in height. There are some geographical variations, however, in which the flowers scarcely overtop the foliage, and still others in which the whole plant is dwarf. Garden hybrids with *Iris orientalis* appear and form an intermediate series, in which are included all shades of blue-purple from the very darkest to faintly tinted, as well as pure white.

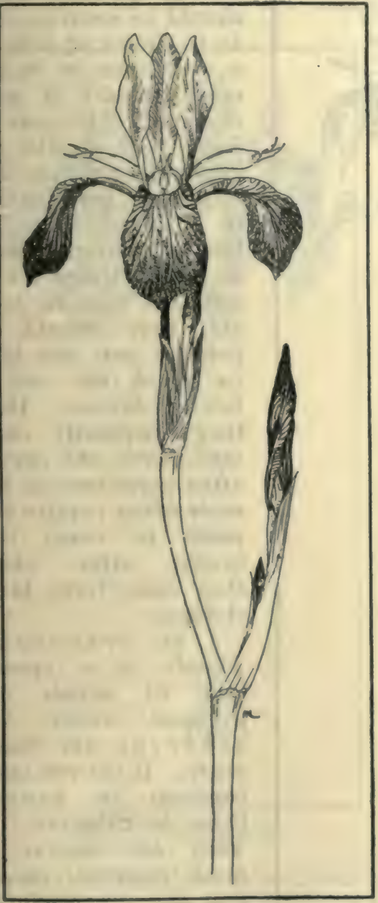

FIG. 2.—*Iris sibirica*

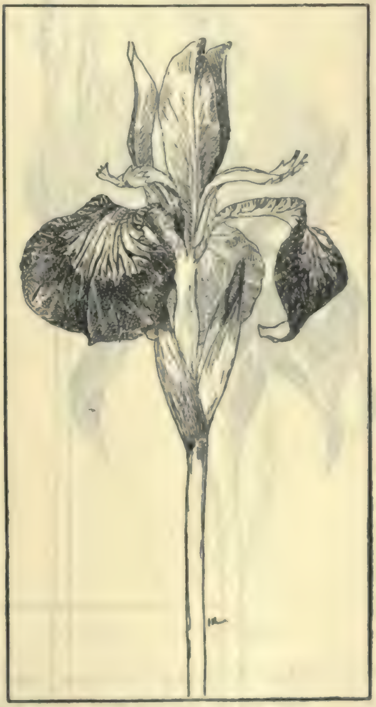

FIG. 3.—*Iris orientalis*

The plants are successful in any moist garden soil and look especially well when planted upon the shores of streams and ponds, but not in such positions as would be covered with water in the win-

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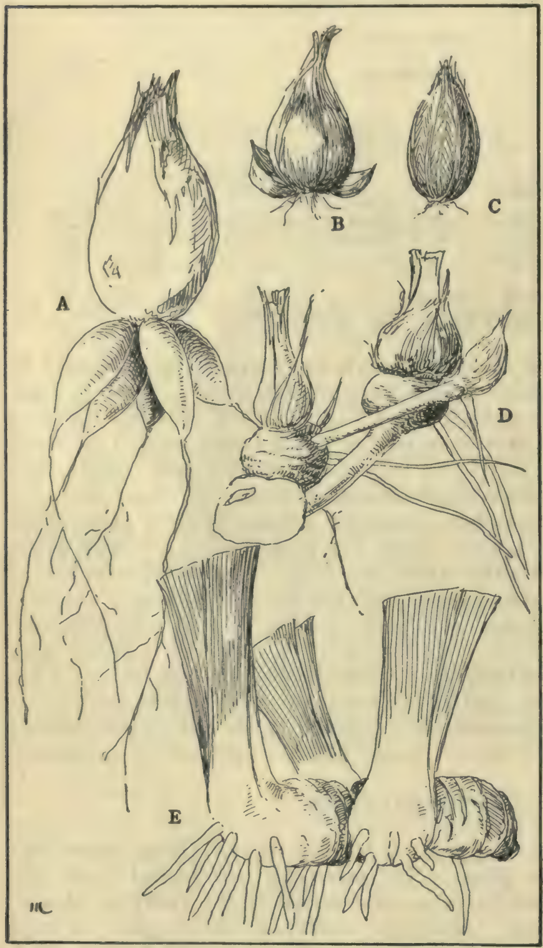

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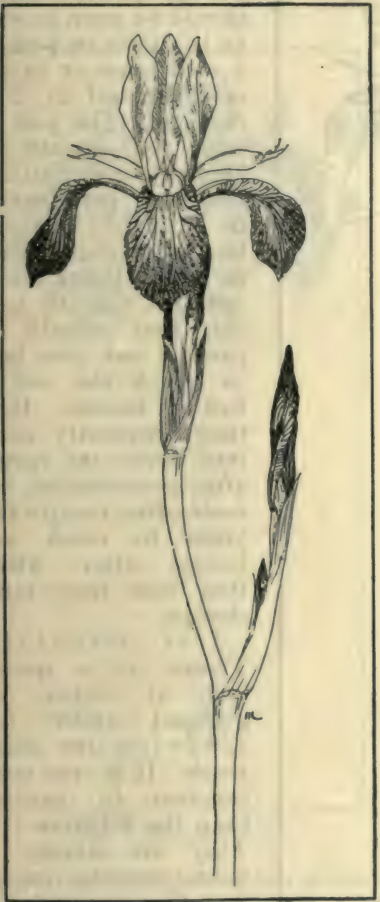

FIG. 2.—*Iris sibirica*

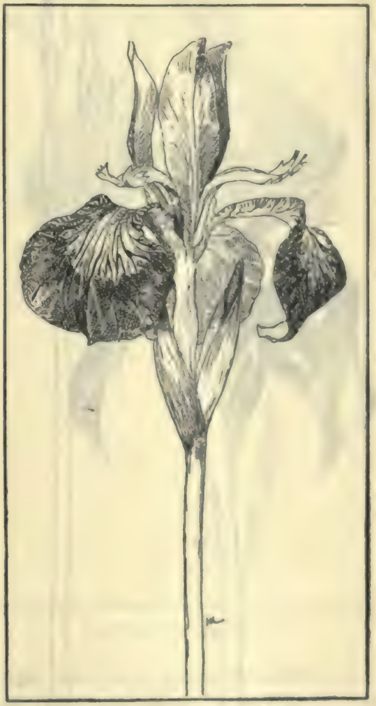

FIG. 3.—*Iris orientalis*

The plants are successful in any moist garden soil and look especially well when planted upon the shores of streams and ponds, but not in such positions as would be covered with water in the winter; for, although the plant is winter hardy in the extreme, it can not survive freezing in saturated soil. If fertilizer is needed, it should be old well-decayed manure but not bone meal, which is used freely on many other kinds of irises.

The plants are propagated by division of the clumps in spring or in late summer, but show preference for spring moving. All the varieties come freely from seed, which should be sown as soon as it ripens in pots in a coldframe or in the open ground in mild climates. The pots or seed bed should be kept rather dry, to discourage germination in autumn. The following spring, as soon as the seedlings are of sufficient size to handle, they should be pricked out into beds in which the soil is full of humus. Here they frequently come into flower the spring after germination, but more often require two years to reach maturity, after which they soon form large clumps.

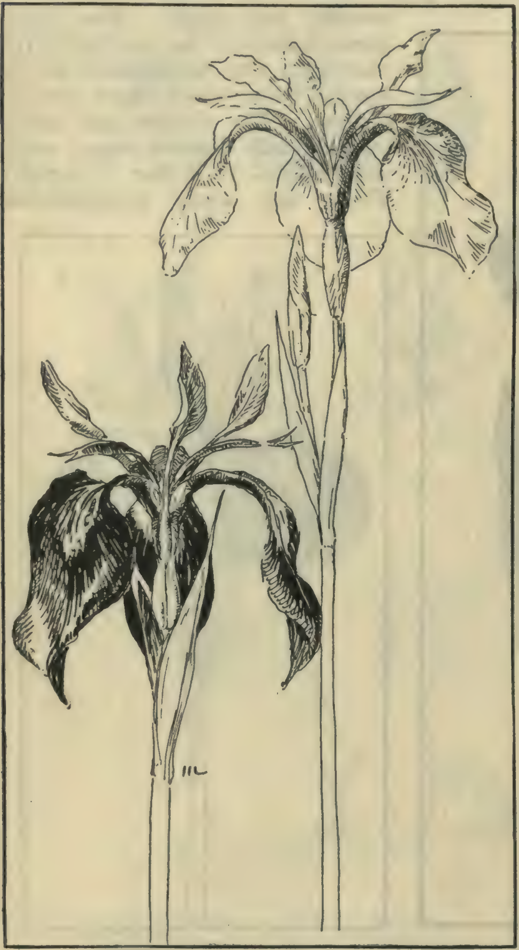

FIG. 4.—*Iris chrysographes* (at left); *I. wilsoni* (at right)

Iris orientalis Thunb. is a species (fig. 3) which was grouped under *Iris sibirica* for many years. It is even more common in gardens than the Siberian iris. They are similar in most respects, except that the plant of *Iris orientalis* is stouter in all its parts and that the flowers have larger falls (see fig. 49) and are borne on stems that scarcely top the foliage. Its hybrid forms, which perhaps have in them some of the blood of *Iris sibirica*, have taller stems and in the cases of the varieties Blue King, Emperor, and Snow Queen are notably fine plants. In culture and propagation the species are alike.

A few species closely related to *Iris sibirica* are found in gardens but are for the collector rather than the amateur, with the possible exception of *Iris prismatica* Pursh, a charming slender iris native of the swamps and moist meadows of the northern United States. *Iris forresti* Dykes has beautiful pale-yellow flowers, as has *Iris wilsoni* Wright (fig. 4); *Iris chrysographes* Dykes (fig. 4) bears gorgeous royal-purple flowers with intense gold marked on the falls; and *Iris bulleyana* Dykes has deep lavender flowers mottled with rosy purple. All of these have flowered in the writer's garden, but *Iris wilsoni* alone persists in fair health, and similar reports are known from most of the Eastern States for all save *Iris chrysographes*, which is sometimes contented.

The Japanese irises have a horticultural origin in which it is believed that *Iris kaempferi* Siebold has been the predominating factor. This is borne out by the evidence that seedlings from the named Japanese irises often revert in part to small forms which closely resemble the wild *Iris kaempferi* (fig. 5). Unfortunately we shall never know what other species were involved, as there are no available Japanese records. The other species native to Japan which might have been used are *Iris laevigata* Fischer (fig. 6), which is largely grown in its several forms, and *Iris setosa* Pallas, which also occurs but is not used in the Japanese gardens.

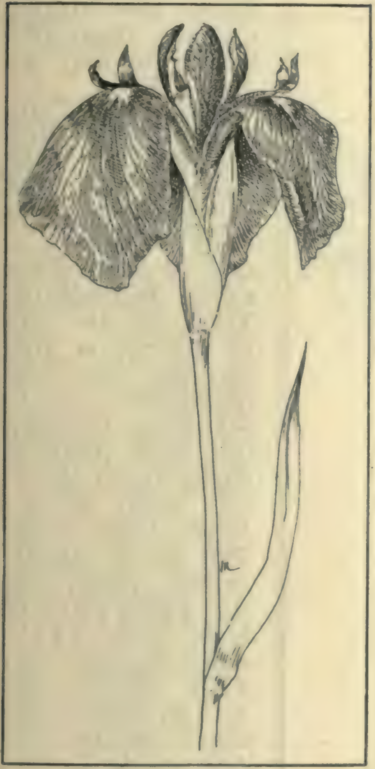

FIG. 5.—*Iris kaempferi*

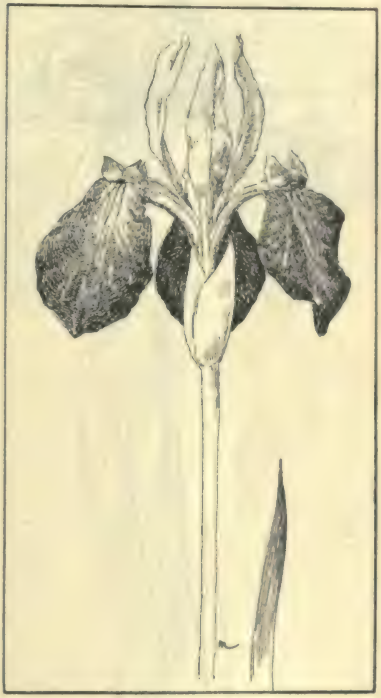

FIG. 6.—*Iris laevigata*

All the Japanese irises (fig. 7) are beautiful in flower, though some are finer than others, the chief faults appearing in varieties in which the flowers are too heavy to be held erect and in colors which are not clear but mottled and streaked. This objection does not extend to those varieties which are distinctly veined or are marked with bands or zones of clear color.

The plants should be propagated by division or by seed and treated like the Siberian irises, noting only that to obtain the finest blooms extra feeding with liquid manure should be given just before blossoming. It should be remembered also that seedlings will vary greatly in color and size of flower and that the plants which are given ample food will require more frequent division than irises left to ordinary border culture.

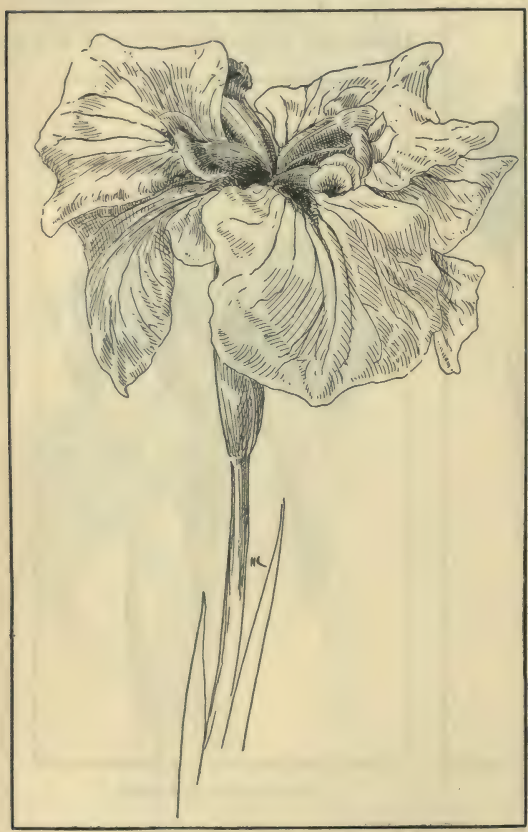

FIG. 7.—A Japanese iris

Irises of another group in this section are not so widely grown as they should be, their chief fault being that they are slow of establishment after transplanting. These are the irises of the Spuria group and are most often represented by *Iris ochroleuca* L., one of the most beautiful, especially on the Pacific coast, where it forms huge clumps. This iris is a striking garden plant, with stiff leaves 3 to 4 feet high, with taller stalks bearing large white flowers, each with an intense yellow blotch on the falls. *Iris spuria* L. itself (fig. 8) is similar in shape and size, but has flowers of varying shades of lavender. *Iris aurea* Lindley is a gorgeous deep-yellow form with rather wider falls than the others.

All of these, together with the hybrids between *Iris spuria* and *Iris monnieri*, are plants that require full sun, an abundance of water during the spring, and a thorough rest in the late summer, preferably with a natural climate of heat and drought. In spite of this they do well in the Eastern States and are hardy as far north as New Hampshire. When successfully established they should not be disturbed. Propagate by division in spring or immediately after flowering, if this does not precede a seasonal drought. Propagation by seeds is very slow and not worth while in ordinary garden practice.

One other small closely related iris is the dwarf *Iris graminea* L. (fig. 9), which should be in all collections on account of its curious flowers and its delightful fragrance, a scent recalling that of freesias. It rarely exceeds a foot in height, so it should be used in the front of the border, where it is entirely satisfied with ordinary garden conditions.

Another garden iris of common occurrence is *Iris pseudacorus* L., the common yellow-flag iris of Europe (fig. 10), of most robust nature, growing freely both in sun and in shade, in dry and in moist situations. For its best development it should be grown in the open with an abundant supply of water. It increases rapidly, soon forming heavy clumps with 4 to 6 foot straplike leaves and flowering stalks scarcely as high. There are many flowers on each stalk, varying considerably in size and in shade of yellow, approaching pure white in some forms, and also in the amount of brown reticulation on the falls.

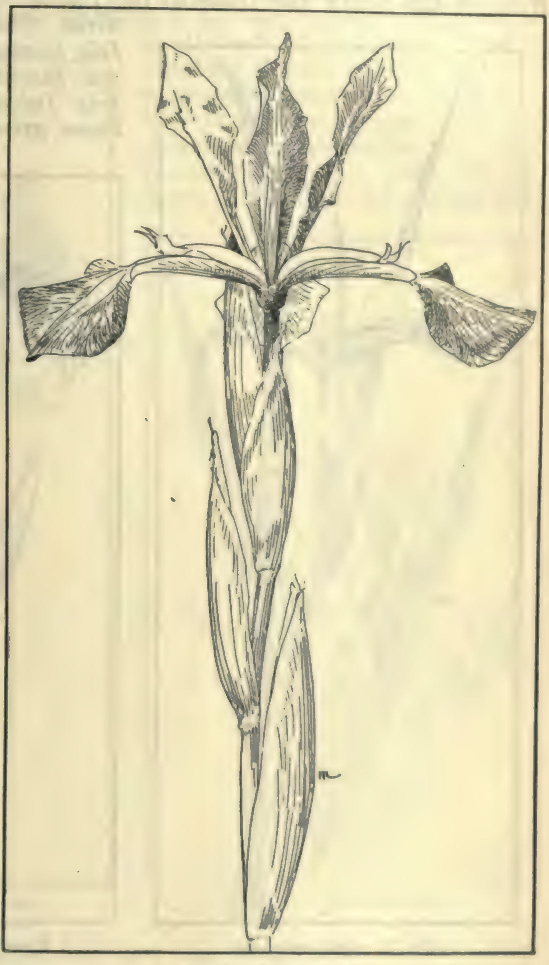

FIG. 8.—*Iris spuria*

This iris is too coarse for most garden plantings, but is admirable for the shores of ponds and streams, where its thick masses of roots bind the soil tightly and prevent its washing away. If grown in gardens the flower stalks should be cut when the last flower fades, to prevent the formation of seeds, which if left to ripen sow themselves and become a weedlike nuisance.

Iris versicolor L., the common blueflag of the prairies (fig. 11), is the American counterpart of *Iris pseudacorus*, though it never reaches the same large size and its flowers are in shades of lavender varying to white, but never yellow. It, too, is useful only for landscape plantings, unless one happens to find a form which is unusually free flowering, as most plants produce so great a mass of foliage that the flower stalks are far outnumbered.

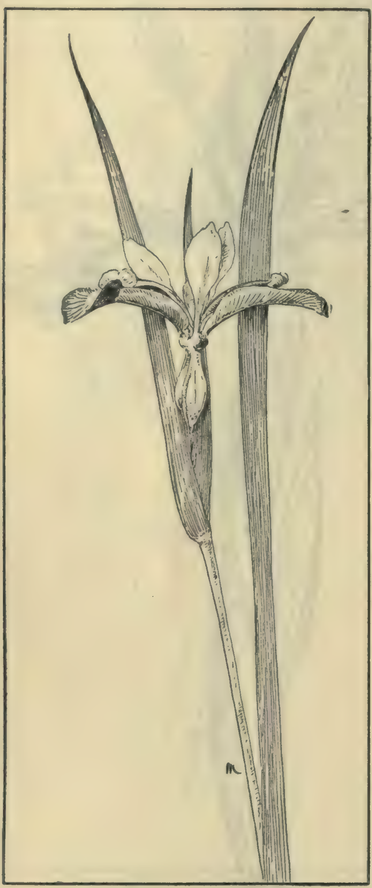

FIG. 9.—*Iris graminea*

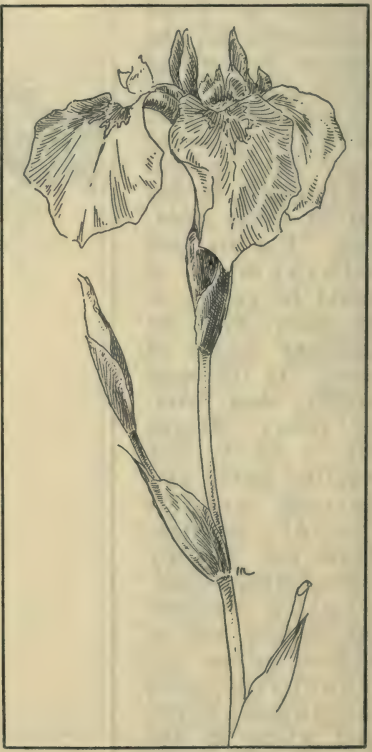

FIG. 10.—*Iris pseudacorus*

Two other groups of American irises should be noted—the wild irises of the South and those of the Pacific coast. The former are three closely related species—*Iris hexagona* Walter, *Iris foliosa* Mackensie and Bush, and *Iris fulva* Ker-Gawl. All of these grow naturally in wet if not swampy places, but thrive very well in ordinary garden soils. *Iris hexagona* is the most tender and *Iris foliosa* the most hardy. The flowers of all are of good size and widely expanded, clear terra-cotta colored in *Iris fulva*, a reddish purple in *Iris hexagona*, and a clear blue lavender in *Iris foliosa* (fig. 12). Pure-white forms appear at times in both *Iris hexagona* and *Iris foliosa*, but are not long lived in most gardens. The plants are easily propagated by division or by seed, which often requires two years for germination. These species are best used as small clumps in the border, and in the case of *Iris foliosa* as a ground cover in half-shaded areas.

The other notable American species are those from the Pacific coast. These are dwarf plants for the most part, with charming little flowers of very delicate coloring. They are somewhat difficult to manage in gardens and are not successful in any climate where winter cold destroys the evergreen foliage. Plants should be secured just as the new growths are starting, as the very scanty root growth is all made at that time. Transplanting should be done as little as possible, because the root system is always meager and the rhizomes are so slender that they perish before new roots can be formed. One of the easiest species to manage in the East has been *Iris douglasiana* Herbert (fig. 13), which has flowers of cream color and lavender, often veined on the falls with darker colors.

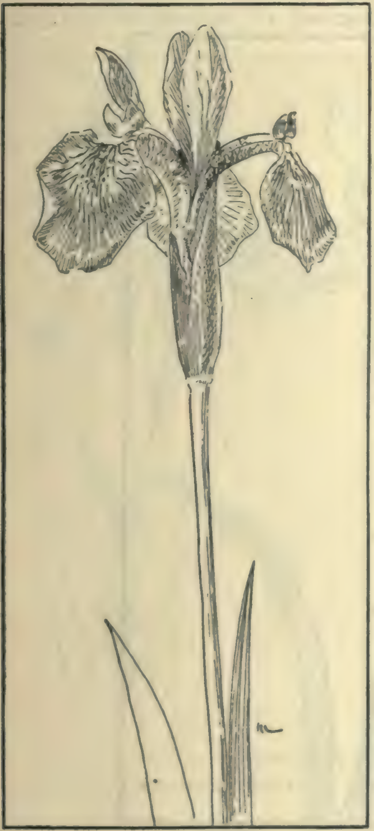

FIG. 11.—*Iris versicolor*

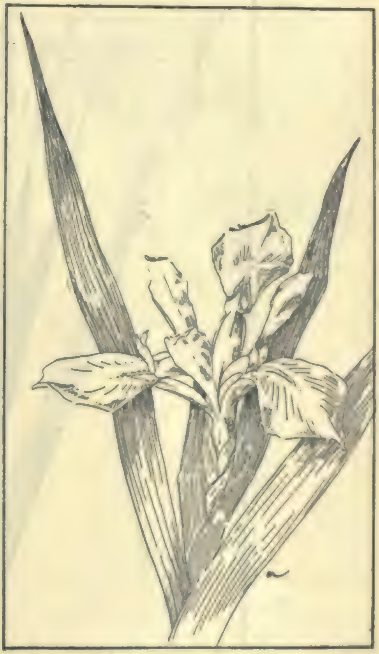

FIG. 12.—*Iris foliosa*

Iris purdyi Eastwood and *Iris bracteata* S. Watson are similar save in the stem characters. *Iris tenax* Douglas from the northern part of the Pacific slope is hardier and more easily grown, but the easiest of all is *Iris longipetala* Herbert, which grows in close clumps with stiff grayish green foliage, slender stalks bearing charming flowers of characteristic shape (fig. 14), and delicate pale-lilac coloring. This is related to *Iris missouriensis* Nuttall of the Rocky Mountain regions and *Iris montana* Dykes, a kindred form; and all are of easy growth in the Eastern States as compared with species from the wooded slopes of the coast countries.

Although the preceding paragraphs do not cover all the interesting irises of the beardless section, they include the most important groups for garden uses. There remain, however, three totally unrelated species which should have passing mention because of their special characteristics.

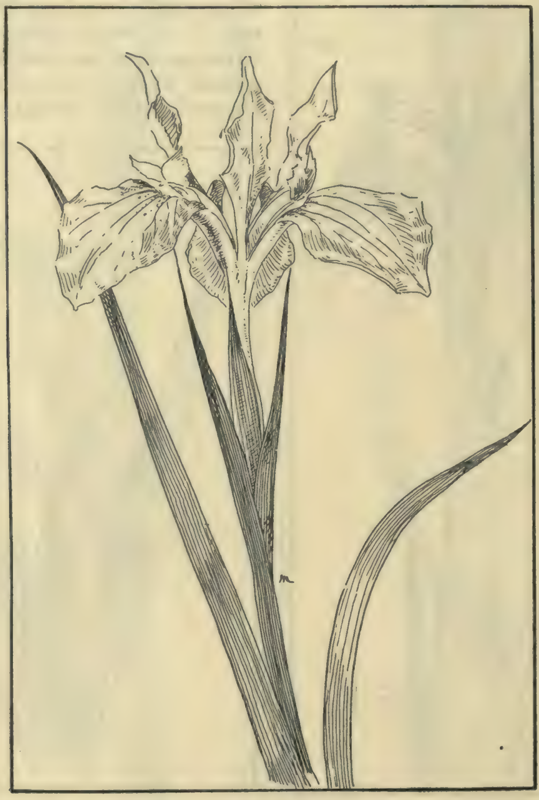

FIG. 13.—*Iris douglasiana*

Least important of these is a native southern iris, *Iris tripetala* Walter (fig. 15), which is related to *Iris setosa* and shares with it the distinction of having standards so reduced in size that they are almost nonexistent. It grows freely in a soil rich in humus and bears its slender lavender flowers late in June, at the same time as the Japanese irises. It should be planted where it can form a mat of foliage, as it spreads by wide stoloniferous offshoots and soon covers a considerable area.

Iris unguicularis Poiret (fig. 16) is a charming evergreen iris from the Mediterranean regions. Its value is chiefly for the South and the Pacific coast, for its flowering season is from November to March. The writer has grown it for years at Washington, but it rarely flowers, because the destruction of the evergreen foliage each winter reduces the vigor of the plant. In several long autumns and in one mild February it blossomed and pushed up its lovely flowers in the frosty air. They are of a beautiful lavender color in the type, but there is an exquisite white form.

This variety should be given a position where it will be hot and dry during the late summer and a soil that is not too rich if an abundance of flowers is desired. Propagation is by division of the roots as growth starts in the spring.

Iris dichotoma Pallas (fig. 17), the third and most interesting of all, is widely distributed in China and is questionably hardy as far north as Boston. It produces tall branching stalks of flowers during the late summer. The stems are leafy, and in general habit the plant resembles the blackberry-lily (*Belamcanda chinensis* DC.). The flowers themselves are small, commonly ivory white with chocolate and dull-purple blotches; but there is a lavender form rather smaller than the type, and among seedlings the writer has a lovely pure-white form.

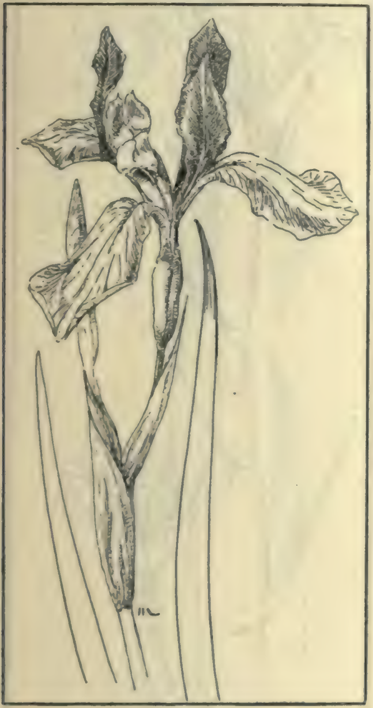

FIG. 14.—*Iris longipetala*

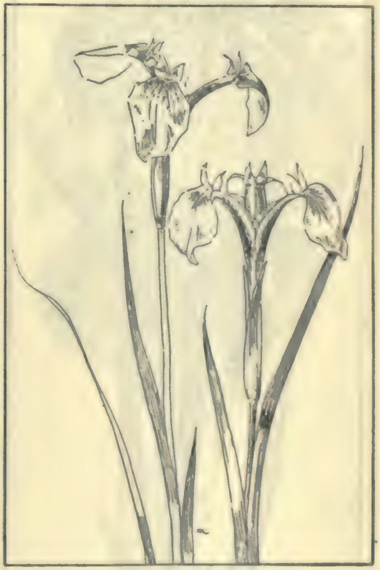

FIG. 15.—*Iris tripetala*

The plant is easily raised from seed, and this is the best way to increase it, as it seems to resent transplanting even in the spring. It requires no special soil, but prefers a rather well drained situation.

The flowers are small but are very freely produced and make a fine show in late August or early September, in spite of the fact that each lasts but a day and does not open until the early afternoon.

ONCOCYCLUS AND REGELIA IRISES

Oncocyclus and Regelia irises are very beautiful and interesting plants from Asia Minor, Palestine, and Syria. They are of difficult culture in gardens except in southern California, where climatic conditions are similar to those of their habitat.

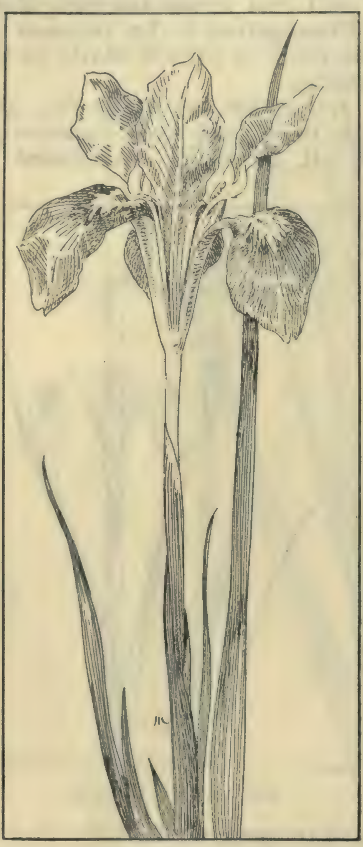

FIG. 16.—*Iris unguicularis*

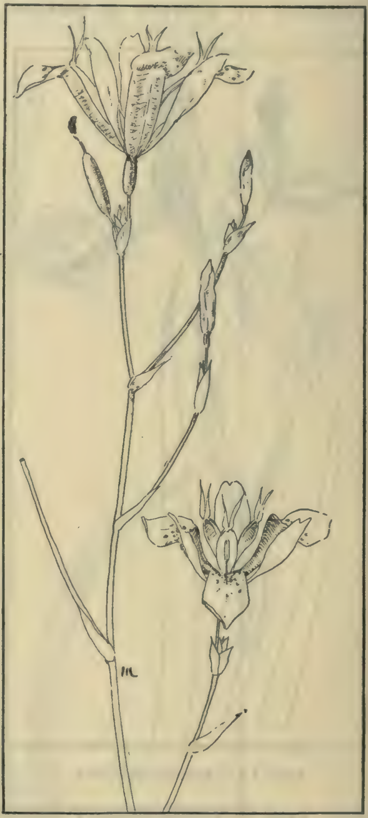

FIG. 17.—*Iris dichotoma*

Botanically they are characterized by seeds with conspicuous arils, rhizomes of short cushionlike growth, and the Oncocyclus species by a diffuse hairy beard on the falls.

Because they are occasionally found in gardens, these irises should be mentioned. For the most part their roots are entirely hardy, but the tops are not, which results disastrously when the plants start into quick growth with the first autumn rains, only to be frozen and destroyed in November.

On the Pacific coast and in the regions where there are marked dry and wet seasons they are more at home, for the autumnal rains are cold and retard the growth until early flowering in March.

In the Regelia group, *Iris korolkowi* (fig. 18) and its several varieties are much easier to manage than *Iris susiana* (fig. 19) of the Oncocyclus group, the other species commonly cultivated, but both prefer a thorough drying in the summer. This can be accomplished by lifting the plant as soon as the foliage shows signs of ripening and storing the rhizomes in a dry state until midautumn, or until the soil is too cold to encourage top growth but not too cold to encourage root action.

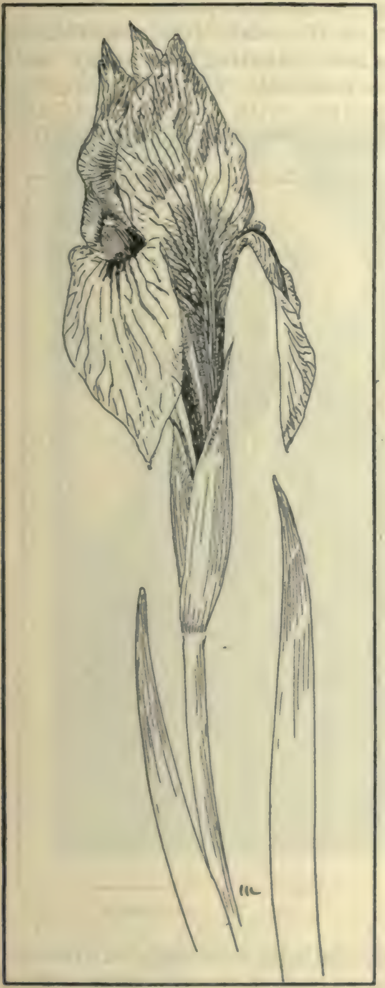

Fig. 18.—*Iris korolkowi*

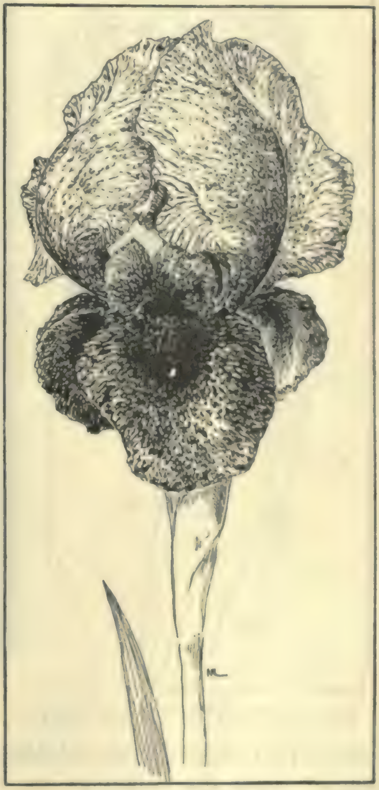

Fig. 19.—*Iris susiana*

Many hybrids between the groups have been made, resulting in wonderfully beautiful flowers (fig. 20), which show some advance in hardiness over their parents but are greatly benefited by similar treatment. Hybrids with members of the Pogoniris group, however, are much hardier but often much less beautiful.

BEARDED IRISES

Bearded irises are the best known of the garden sorts. They are plants of varying stature and size, but all are characterized by stout rhizomes, more or less evergreen foliage, and for the most part brilliant flowers in many shades, each flower bearing on the falls a linear beard of various colors, though commonly yellow.

The bearded sorts are of easy culture if certain fundamentals are observed. All of them prefer shallow planting in sunny well-drained locations in a deep well-worked soil. If planted in connection with other plants they should be arranged so that their surface roots are not overshaded by foliage, especially in the late summer when the rhizomes are being ripened for the next season's flowering.

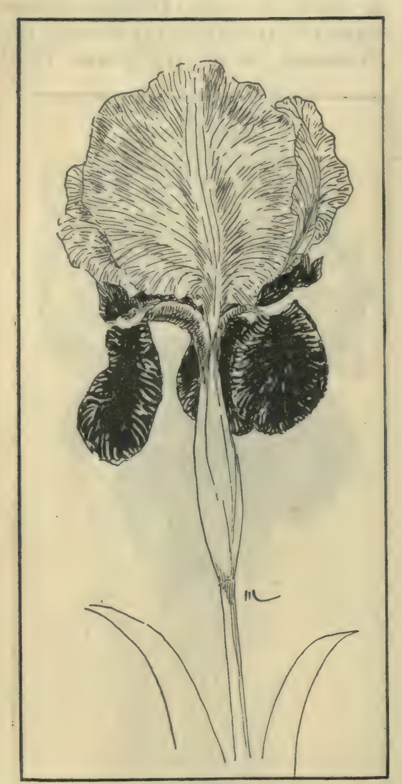

Fig. 20.—A Regelio-cyclus hybrid iris

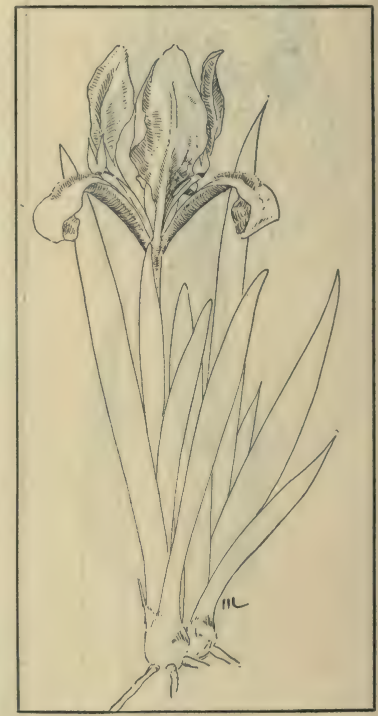

Fig. 21.—*Iris pumila*

Nearly all varieties multiply rapidly into clumps which maintain themselves in fair condition almost indefinitely. For the best results, however, the clumps should be lifted, divided, and reset every fourth year, with an adequate remaking of the soil in the border. This operation should be carried out immediately after the blossoming season, but may be delayed until the early autumn. In regions where there is a sharp drought in midsummer it may be wise to wait until this has passed, unless water can be given to counteract the season and to stimulate root action.

To obtain varieties true to name these irises must always be propagated by division of the roots. Seeds are sometimes produced naturally and can be obtained with some freedom by hand pollination. The practice in planting the seeds varies somewhat. The writer prefers immediate planting, but other workers prefer later planting and have most satisfactory results. The chief possible danger of delay is an excessive drying of the hard seeds, which delays but does not prevent germination. Normally this should come the spring after planting, and the seedlings should grow enough in the season to flower the following spring. It must be remembered, however, that the seedlings will not necessarily resemble their parents and in many cases will be greatly inferior to them.

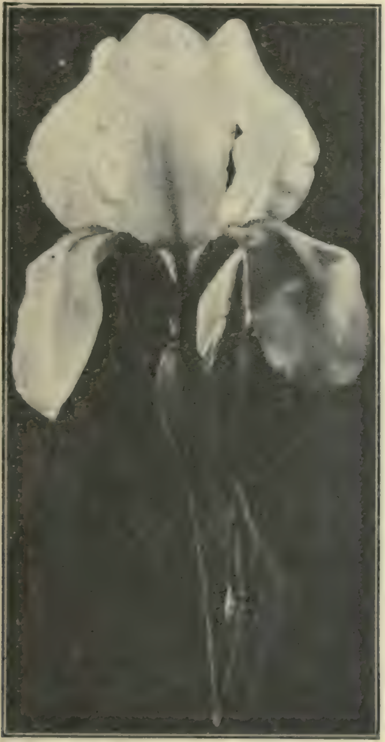

FIG. 22.—*Iris albicans*

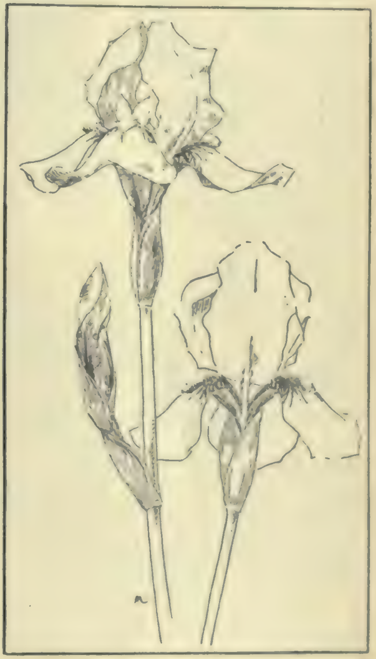

FIG. 23.—Innocenza

In the wild there are several centers of bearded irises in which the members of the group show similarity of characters. These are the irises that grow through northern and central Europe, those of Asia Minor, and those of India. These groups, of course, are overlapping, not sharply defined, and vary within themselves.

Very few of the wild species play a conspicuous part in garden work. The dwarf irises of Europe are represented freely in *Iris pumila* L. (fig. 21) and *Iris chamaeiris* Bertolini, and these have been mixed to a degree with hybrids of other dwarf European species. Of the tall-growing European species *Iris germanica* L. is the most common, with *Iris albicans* Lange (fig. 22) next. The wild types of *Iris pallida* Lamarck and *Iris variegata* L. are rarely grown, as they are now far surpassed by garden forms. From Asia Minor there is *Iris trojana* Kerner, and in favored localities *Iris junonia* Schott and Kotschy and *Iris mesopotamica* Dykes may also be grown. The Indian group is represented by *Iris kashmiriana* Baker, but this thrives only in mild climates.

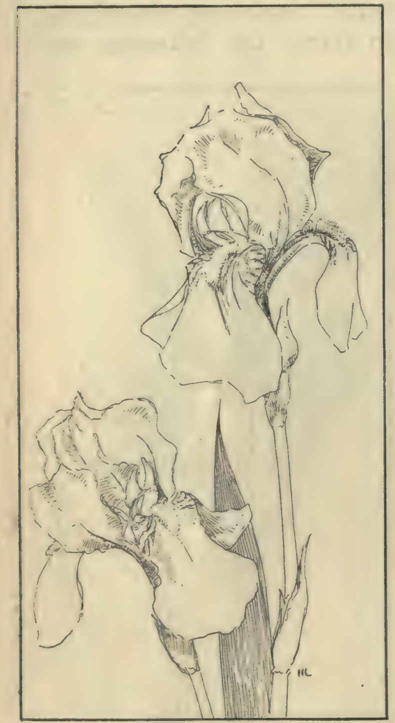

FIG. 24.—*Iris florentina*

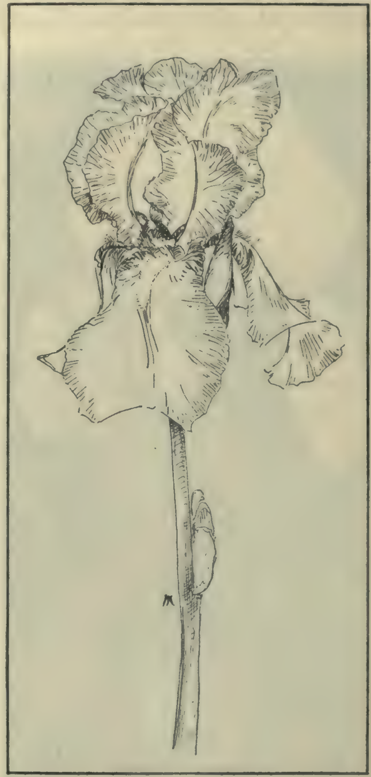

FIG. 25.—Courcy

A certain confusion has arisen in the literature of the iris from the one-time practice of naming some of the early hybrids, both of natural and garden origin, as though they were species instead of garden forms. In time these came to be grouped merely as horticultural forms, but during the last few years interbreeding has been carried on to such an extent that it is almost impossible to place the new varieties in any semibotanical classification, with the result that most gardeners frankly group them by colors, with some notation of the pedigree—a most important item, especially for gardens in the North.

The discussion that follows is therefore based entirely on the garden point of view.

Purely as a matter of convenience the first consideration might be given to the dwarf European species. These are interesting little plants, rarely exceeding 10 inches in height and usually much less than that. There are many color forms in the trade, both of the dwarf stemless *Iris pumila* and of the taller *Iris chamaeiris.* The clearest colors in each case are the reds, violets, and purples. The yellow varieties are oftener tinged with dull olive or purple and the whites with green or slate blue. Almost all forms set seed freely and multiply with considerable rapidity. Because they are dwarf they should be planted near the front of the garden border in irregular patches rather than in formal edgings. The seeds if sown before winter germinate the following spring and soon grow to flowering size. The named varieties — Cyanea, Schneekuppe, White-Edge, Orange Queen, and Bride—make a reasonable selection of colors for any garden. *Iris lurida* is of similar stature but of unknown origin and although it may have little botanical relation to this group is valuable in that it adds the touch of mahogany-red color to those mentioned; it requires similar treatment. The specialist will take pleasure also in *Iris flavissima* Pallas, the sand iris, a charming small plant, not over 4 inches high, which requires a hot location in sandy soil. Where it flourishes it spreads into small open clumps which bear fair-sized golden yellow flowers that open only in the sunlight and last but a day.

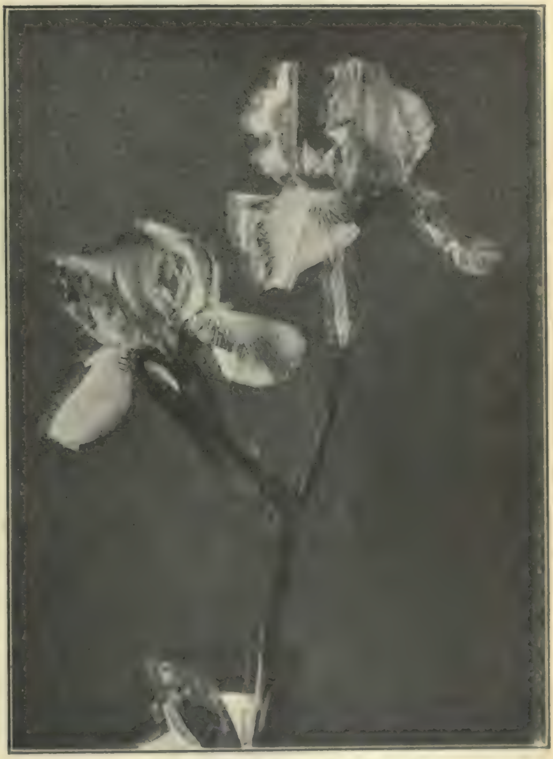

FIG. 26.—Chlorinda

Between these irises and the earliest flowering of the tall bearded sorts, with an admixture of Regelia and Oncocyclus species, some of the early workers, notably Caparne, of Guernsey, England, raised many hybrids which are intermediate in almost all points between their parents and have been so called in the trade lists. They are of greatest use in making continuous the iris season between the April blooming dwarf irises and the May and June flowering tall irises. Ingeborg, Ivorine, Helge, Walhalla, King Christian, Prince Victor, and Blue Boy make a good selection of varieties now in commerce.

Before the mass of named varieties of the late-flowering, tall, bearded iris the amateur may well stand dismayed. This is the group which has received the full impetus of the revival of interest in the iris, and to it have been made the contributions of the many hybridizers who have worked through the last few years.

These are known often as German irises, a most unfortunate common name, inasmuch as it is based upon the false assumptions that the varieties are all related to the Linnæan species *Iris germanica*, a species which is now questioned by many botanists as of possible hybrid origin, and that that species is a native of Germany.

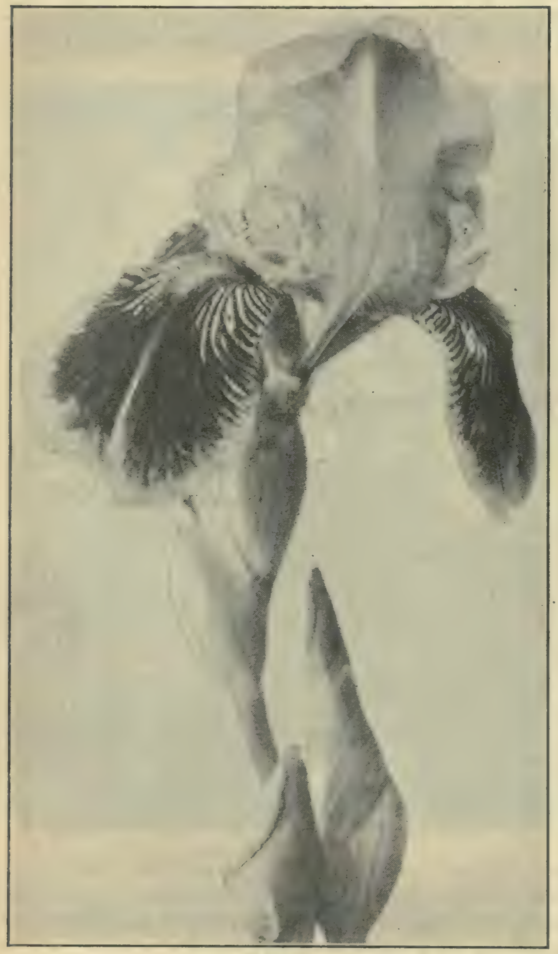

FIG. 27.—Monsignor

In the older catalogues and literature certain group classifications were maintained with semibotanical names, which in the first years served well enough. Since then interbreeding and the introduction of new blood have destroyed many of the definitive characteristics which established the classification.

The best groupings offered so far for the classification of these irises are color groups, in spite of the fact that one is immediately confronted by the difficulties arising from lack of a common understanding of color terms. Individual varieties can be described with absolute accuracy by use of some standard color chart, but such definiteness can not be extended to large groups.

Beginning with the white varieties, there is a group in which are included the truly white ones, as, for example, *Iris albicans* (fig. 22); those which are white with some colored reticulations in the throat, as in Innocenza (fig. 23) or Mrs. Horace Darwin; those of white faintly washed or tinted with color, but still counting for white in garden effect, as in *Iris florentina* (fig. 24), and perhaps as in Pancroft, which may be taken as the other extreme of tinting; and finally those irises which are faintly reticulated with color over their entire surface or along the borders of the segments, as in Courcy (fig. 25), Madame Chereau, and Ma Mie. This explanation alone shows the looseness of the classification, but garden use, which shows all these irises as truly white in effect, warrants the scheme.

Among the self-colored yellows there is little confusion, as they are relatively few in number and limited in range of tint. Among them should be included also those few varieties, like Minnehaha and Chlorinda (fig. 26), which are sparsely reticulated in color on the falls.

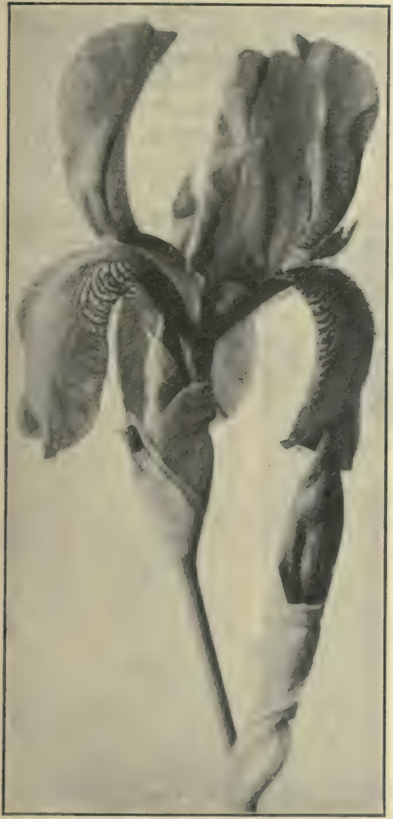

FIG. 28.—Eldorado

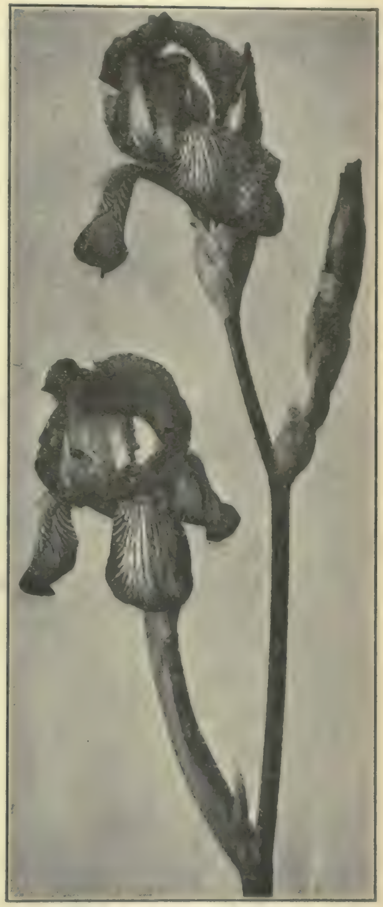

FIG. 29.—Demi-deuil

Similarly, there is no particular difficulty in grouping irises with a strong difference in the colors of the standards and falls. There are those with dark (often velvety) purple falls and standards of shades varying from pure white, as in Rhein Nixe and Thorbecke, to dark lavender, as in Monsignor (fig. 27) or Nine Wells. Correspondingly, there are those in which the standards are of some hue of yellow with falls dark as before but of rather dull purple, brown, or reddish tone, as in Nibelungen or Knysna.

The great difficulty comes in grouping the large number of irises which are of lavender and its related shades. Lavender, lilac, and purple all come from the admixture of blue and red in various proportions, and a further series can be made by diluting all these colors with white or by slightly dulling or neutralizing them toward gray.

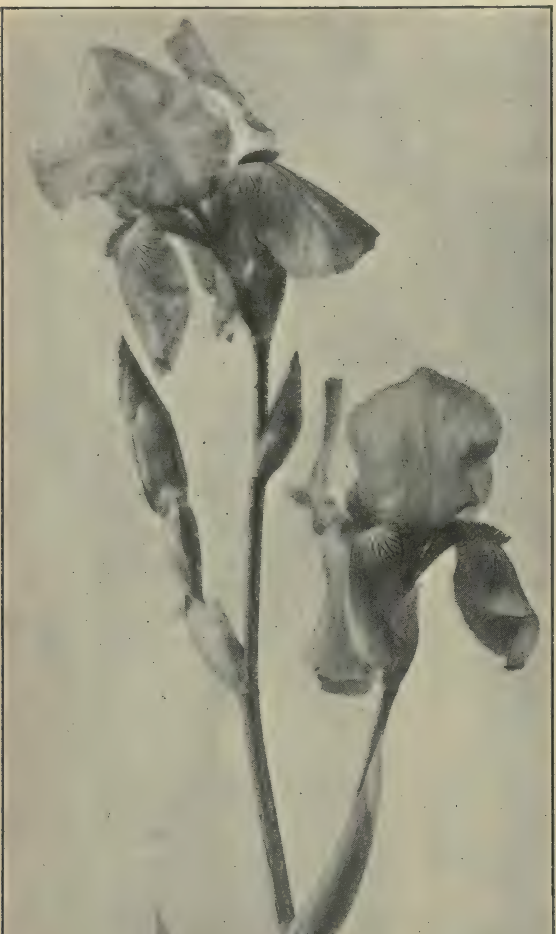
FIG. 30.—Merlin

In iris flowers there is no true blue, for in every case there is blended some red, and the nearest approach that one finds to pure blue is in those flowers, such as Celeste or Moonstone, in which the color is a very dilute tint of lavender containing little red. For these reasons the terms "lavender" and "violet," which are commonly used to describe the iris color, have been hyphenated, and the classification divides those closely related colors into two groups, the red-violets and the blue-violets. In the first group are all those irises in which the color shows slightly more of red than of blue, whether it be in the intense purple of Parc de Neuilly or in the dilute Chinese violet of such varieties as Mrs. Alan Gray, Pauline, or Edouard Michel. The classification further divides into groups those varieties which are self-colored and those which are bicolored. It does not include those varieties, however, in which the difference in the texture of the fall is apparent as well as the difference in color. For example, Oriflamme is a blue-violet bicolor of this group and not of the group of which Monsignor, Perfection, and Nine Wells are examples. Most irises of this group trace their origin to *Iris trojana* or *Iris amas*, whereas the bicolors with a velvety texture have somewhere in their lineage *Iris variegata*. This may not be immediately apparent in the known lineage, but it has appeared in all the breeding experiments of the writer and in others known to him.

There remains a large group of irises, which is constantly increasing as the work of the modern breeder continues. This is the group in which two or more colors are blended in a single petal. If the resulting color is alike in fall and standard the blends are spoken of as self-blends, but if there is a sharp differentiation in standards and falls the plant is called a blended bicolor. Eldorado (fig. 28), Quaker Lady, and Afterglow are examples of the first type and Isoline, Jacquesiana, and Arnols of the latter.

A single group remains which has appeared in its extreme examples in the group of whites. It is the group of flowers in which the pigment is confined to the veins, whether over the entire surface or along the margins. When it appears only on the margins in very slight amounts or over the entire surface in very light colors, as in Mrs. Reuthe, the iris appears as white; but when the border color is dark, as in Madame Chereau, E. L. Crandall, or Francina, or over the entire surface, as in Parisiana, Madame Chobaut, or Mercedes, the flower takes the predominating hue as its garden color. It is interesting to note here that these irises, originally known only in shades of lavender or violet on white, now include faint yellows, as in Pancroft, Montezuma, and Onnoris, browns, as in Demi-deuil (fig. 29) and Madame Denis, as well as deep mauve, as in Parisiana and Mercedes.

Although specific varieties have been named to illustrate the points made, there is no permanent value in listing varieties for garden planting at this particular time when breeders and growers alike have brought to the iris a wave of popularity which is by no means at its peak, but a few generalizations as to the selection of varieties may be of value. Varieties in which the blood of *Iris variegata* appears in not too dilute amounts are more commonly hardy in the northernmost States than many others. The pure pallidas and cengialtis are also hardy, but varieties in which appear the blood of *Iris amas*, *Iris trojana*, *Iris mesopotamica*, or *Iris ricardi* are relatively less hardy. It is not always possible to tell the parentage of varieties, but there are a few features which often betray origin. *Iris amas* bequeaths its offspring low stature with flowers of good size, commonly held fairly close to the stem, together with a slow rate of increase and a type of rhizome division that is very characteristic. There is also a tendency to shy flowering. Although it has never been stated, to the writer's knowledge, Oriflamme is probably from this source, and such varieties as Lord of June, Halo, Myth, Merlin (fig. 30), and Rangoon all point to amas blood. *Iris trojana* and *Iris mesopotamica* both produce seedlings of large size with tall widely branching stems, sometimes too weak to bear up the flower. Alcazar, Caterina, Asia, and Impresario (fig. 31) are excellent examples of these irises. They do best in climates not severe enough to injure the strong tufts of foliage which develop in the late autumn. For this reason these irises reach their optimum development on the Pacific coast.

CRESTED IRISES

Crested irises are very lovely and two of their species should be found in every good garden. The one is *Iris cristata* Solander (fig. 32), a native of the eastern United States, extending westward through the mountain regions to the shores of the Great Lakes in the North and to the Ozarks in the South. It is a dwarf species with creeping rhizomes and broad green leaves about 6 inches high that form a delicate carpet through which appear the brilliant pale-lavender flowers with their crested falls marked in white and orange. There is much delicate variation both in coloring and amount of these markings, but not sufficient to distinguish varieties save in the pure-white form with its crested golden blotch.

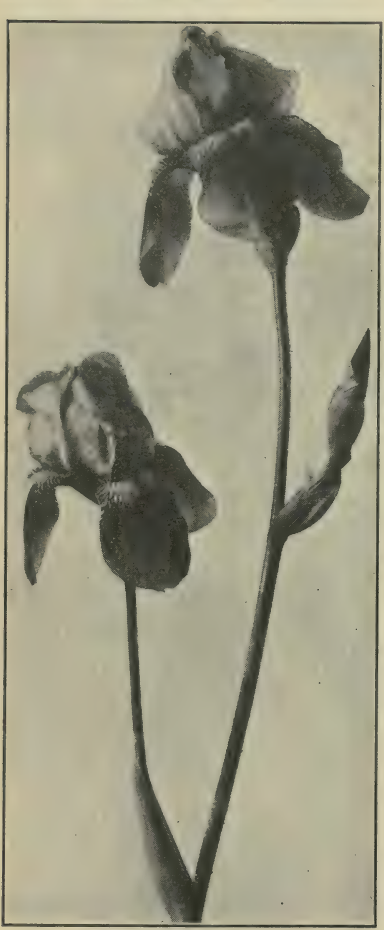

FIG. 31.—Impresario

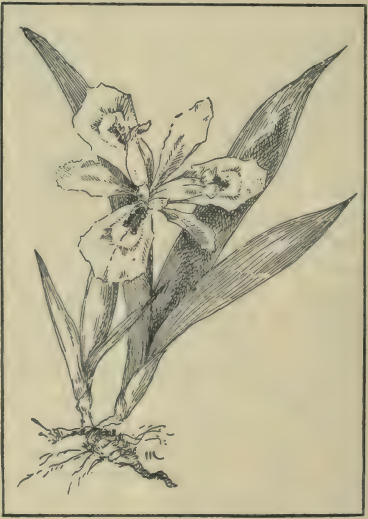

FIG. 32.—*Iris cristata*

Iris cristata is easily propagated by division in the spring, before active growth commences, or in late summer. It prefers a cool soil in semishade. Seed is produced freely, but seedlings never appear in the gardens the writer has known and he has had no success in germinating seed ripened in his own garden. The plant would make an excellent ground cover.

The other charming representative of crested irises is the still smaller *Iris gracilipes* A. Gray (fig. 33) from Japan. This is of similar stature but has narrow leaves of a distinct yellow-green color and dwarf branching stems which bear small rosy lavender flowers marked with white and yellow.

In both the preceding species the crests which distinguish the members of this group are small and inconspicuous, but in *Iris tectorum* Maxim (fig. 34), the other semihardy member of this division common in this country, the crest is a distinct addition to the beauty of the flower. This iris is of the easiest culture in any good garden soil either in shade or sun, but suffers in climates where the winter is severe enough to freeze the evergreen foliage. This so reduces the strength of the plant that the little vigor remaining is not sufficient to produce good flowers. In frost-free climates it grows almost too luxuriantly, so much so that it produces great sheaves of broad foliage and no flowers. It seeds freely, and the young seedlings come quickly to flowering.

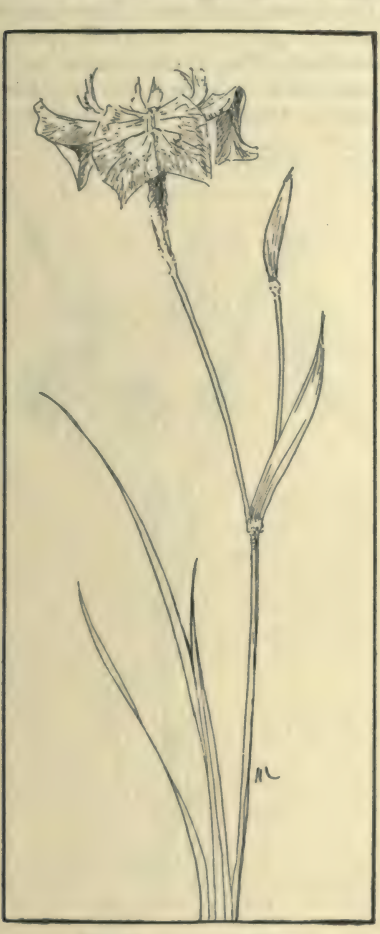

FIG. 33.—*Iris gracilipes*

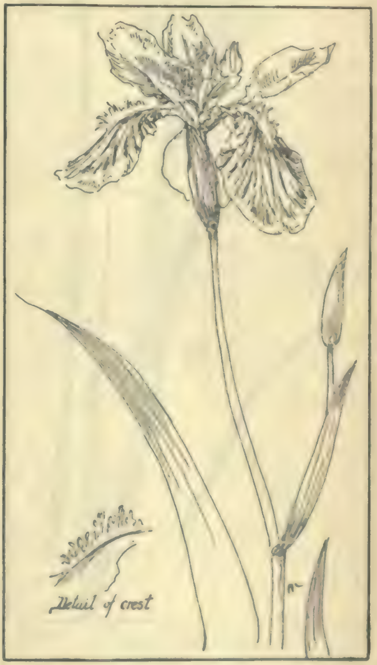

FIG. 34.—*Iris tectorum*

The plant is apparently more or less indifferent to lime and requires no special care in the matters of watering or drought.

There is an exquisite white form which comes true from seed if self-pollinated.

BULBOUS IRISES

THE XIPHIUM GROUP

The bulbous species of most use to the American grower are the so-called Spanish, English, and Dutch irises.

The Spanish irises are a strain of more or less uncertain origin. They embrace many color forms and are the result of years of patient evolution at the hands of European growers. The typical wild form of *Iris xiphium* L., which is the accepted original species, is blue. The horticultural forms can now be had in far more colors than the original blue of the wild iris. There are few records definite enough to determine whether the color variations have arisen purely in variations from seed or sport or by the intermixture of the blood of allied species, few of which have come into culture themselves. The Spanish irises are slender plants with very narrow leaves and flower stalks about 18 inches high, bearing at most two flowers of a very characteristic shape not duplicated elsewhere in the family except to a degree in the Spuria groups of the rhizomatous section. Figure 35 shows most clearly the slender form of the perianth segments with the erect standards and narrow falls almost covered by the overarching style arms.

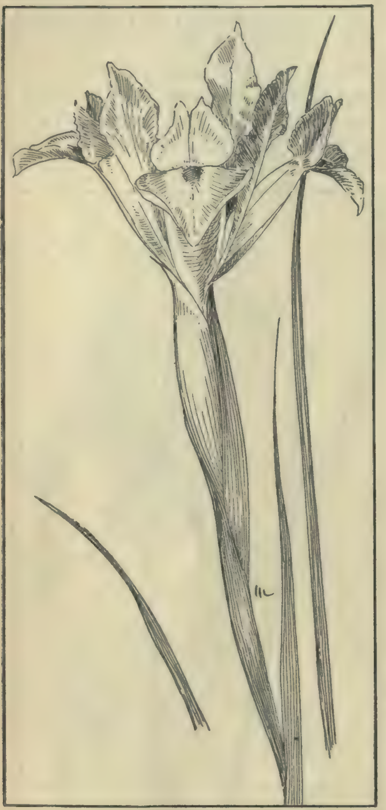

FIG. 35.—*Iris xiphium*

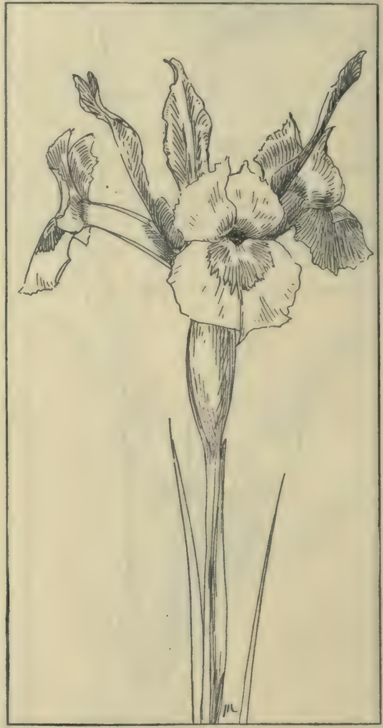

FIG. 36.—Dutch iris

The nearest relations of the Spanish irises are to be found in the new race of Dutch irises (fig. 36), which are similar in most of their parts and differ chiefly in somewhat earlier flowering, in size, and in heavier petal texture. It is interesting to know that this race was brought about in an attempt to discover the origin of the Spanish irises by various crosses of *Iris xiphium* L., with its variety *praecox*, *Iris filifolia* Boiss., *Iris lusitanica* Ker-Gawl., and others.

Both Spanish and Dutch irises are of easy culture in most regions. They do not thrive in the extreme North or in any climate where the autumn growth is likely to be injured by frosts. An autumn growth of foliage appears in many irises and is a safe indication of origin in regions where there are no severe winters, winters at least lacking in heavy snows and repeated freezing and thawing. In the case of the Spanish iris the growth is rarely more than a single spear-like leaf, which attains a height of 6 or more inches in the late fall and remains so throughout the winter except in the South and on the Pacific coast, where the mild weather in one case and the winter rains in the other encourage continuous growth and a correspondingly early flowering.

The irises in the Xiphium group prefer a sunny rich soil of moderate moisture during the early summer and of some dryness during the late summer. In regions such as the Middle Atlantic States, where frequent summer rains would often work havoc with them, the danger can be overcome by planting in soils that are light, warm, and thoroughly drained. In such soils they are relatively permanent but slow of increase.

These irises can be grown from seed, which is often freely produced; but the small bulbs take a long time to reach flowering size, and the formation of seed so reduces the strength of the bulb that it is often prevented from flowering the following year.

At the present time these irises are chiefly cultivated on the Pacific coast and in lesser numbers in the South. They are found in many gardens throughout the Eastern States, where they have been permanent for years.

These irises are essentially garden flowers, as the plant is of too delicate a structure to hold its own in any landscape planting. For this reason they should be planted in groups, never singly, and should be surrounded by perennials that will partly occupy the space left by the ripening of their flower stalks. Care should be taken that they are not overcrowded, as the sun must reach the soil to ripen the bulbs sufficiently for next year's flowering.

Perhaps a size larger in all parts than either of these irises and later flowering in season are the English irises (*Iris xiphioides* Ehrh.). These have been introduced into this country with some difficulty, on account of the losses in transit, and are not well known. They are reported to be succeeding excellently in the State of Washington, where they seed freely and where the seedlings come to maturity after a tolerable delay.

The chief advantage of the English over the Spanish irises is a larger flower with better developed blade in the fall. They are taller and require a moister soil than the Spanish irises; and they do not have the range of coloring, as there are no yellow or bronze varieties. They are both alike, however, in being strictly garden plants.

All members of this group are valuable for cut flowers, as they can be forced gently, and unlike most irises they stand transportation well.

THE RETICULATA GROUP

The Reticulata group can be given only passing mention because it is practically not available for the average grower. However, there are scattered over the country many isolated gardens in which old clumps remain and delight the owners in early spring with their richly colored flowers (fig. 37). They are reported to prefer an alkaline soil of a light rather than a heavy nature.

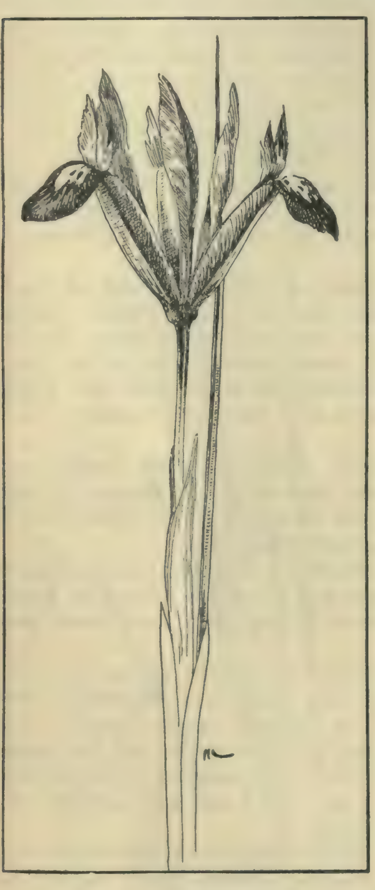

FIG. 37.—*Iris reticulata*

THE JUNO GROUP

The Juno group of irises, like the preceding, is rarely to be met in gardens of this country but would probably succeed admirably in many sections.

The large bulbs (see fig. 1) are almost as impatient of disturbance as are peonies, because of inevitable injuries to the storage roots; but when once the plants are established in a warm, rich soil they increase to clumps and form interesting members of the garden family. They always attract attention, because they are early flowering, blooming immediately after the dwarf pumilas, and because of their unusual appearance. Unlike all other irises they develop a stalk upon which the leaves are borne, forming a plant strikingly like a miniature Indian corn. In the axils of the upper leaves are borne the brilliantly colored flowers.

In the writer's experience the small *Iris rosenbachiana* Regel is the first to appear, in mild winters flowering in late February in the vicinity of Washington, D. C. In it the short stems are not developed at flowering time, and the blooms seem to rise successively from the enfolding sheaths at the surface of the ground. The flowers are variable in color, but are mostly of rosy lavender with markings of darker purple and gold. *Iris orchioides* Carrière in its typical yellow form (fig. 38) and its white and blue varieties follows quickly, and later comes the gorgeous *Iris bucharica* Foster, with white standards and deep golden yellow falls. There are other members of this group of equal or greater beauty, but they have not been grown by the writer.

Those grown have flourished and increased in deep garden soil of light texture with full exposure to the sun. Seed is produced freely by *Iris bucharica* and moderately by the other sorts mentioned, but the resulting seedlings are slow of growth. The one drawback in the culture of these sorts is their early growth with consequent susceptibility to early frosts. In cold climates they should be given some protection, not for the bulbs, which seem entirely hardy, but for the foliage. In frost-free regions they should develop amazingly.

In this résumé of the botanical groups the gardener can find an indication of nearly every kind and type of iris he is likely to meet in his garden experiences. Many of them are of more botanical than horticultural interest to beginners, but those which have been described are easily within the skill of the careful cultivator. This review does not include the descriptions of the masses of horticultural varieties, which are constantly changing and are usually adequately described in the trade lists and in the bulletins of the American Iris Society.

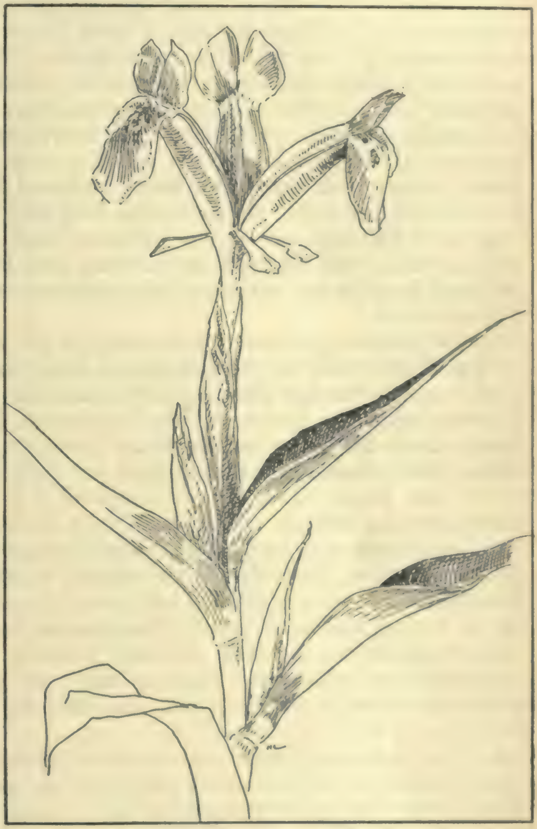

FIG. 38.—*Iris orchioides*

GARDEN USES

When one considers any flower to determine its merits there are three points of view from which it must be judged: The viewpoint of the landscape architect, that of the gardener, and that of the florist. Few flowers are of equal value to all three. The florist's roses are often valueless in the garden and of still less value in landscape planting.

The iris follows an inverse ratio. Very few are of value to the florist, nearly all are of prime importance to the gardener, and many are of value to the landscape gardener in naturalistic plantings.

To be of value to a florist a flower, quite aside from its sentimental characteristics, must have qualities of petal and shape of bloom which will facilitate shipping in a cut state and have a moderate duration after sale. It must also have a season of bloom, either natural or forced, which will not encroach upon the established seasonal flowers, unless it has sufficient quality and character to usurp their market position.

The iris of to-day does not meet these requirements. Its flowers are fugitive, of very delicate substance, with few exceptions easily spoiled even with the most careful handling, and again with few exceptions blooming naturally at times when the market is glutted with bloom. It is forced with great difficulty. There are notable exceptions in the Spanish and Dutch irises and some few of their allies, notably *Iris tingitana* Boiss. and Reuter, which if forced moderately yield excellent flowers for cutting purposes. For the best results the bulbs used must come from regions where they are adequately ripened by summer heat and drought. They should not be forced until after New Year's and should be grown slowly, as too rapid forcing will cause the bulbs to come blind. The flowers can be cut when the color shows in the bud and shipped even from Los Angeles to Chicago before the petals unfold.

Other irises can be used for cutting and for decorations if grown and used locally, but commercially they are scarcely worth the effort of production.

In the garden, however, the story is very different. Here there are few flowers which yield so lavish a return for so small an effort. In the mixed border the iris furnishes the most important climax of bloom after the spring bulbs. In nearly all localities they follow closely after the Darwin and May flowering tulips, the last of the tulips often combining charmingly with the earliest irises. In the border the plants should be spaced so that they can develop into clumps strong enough to carry 8 to 10 stalks of bloom. It is absolutely essential that the plants surrounding them should not grow over them after their flowering season, as shade over the rhizomes prevents the proper ripening of growth and results in the curtailing of bloom the next year. The flower buds for the next season are formed in late summer or early autumn and develop best when the plants are otherwise inactive save for root growth. For this reason it is better to do any transplanting either before or after this time.

As to the arrangement of varieties, much must be left to personal taste. A few general suggestions are permissible. Better effects are secured oftentimes by the gradation of colors rather than by alternations of contrasting hues. For example, gradations from white through pale yellow to dark yellows and bronzes, through pale lavenders to dark purples, or through pale pinks to dark red-violets are all more likely to be effective than a sequence of white, purple, yellow, pink, lavender, bronze, and so on. Nevertheless, in mass plantings of either light or dark sorts it pays to introduce clumps of dark or light varieties merely to give accent to the mass. At other times it is better to secure this by means of some other plant than iris, such as hemerocallis or early-flowering peonies. Hemerocallis blooms in their shades of pale yellow and orange are particularly effective with the lavender and purple irises, whereas peonies in white and pale pink are better with irises of pink or mauve shades or of pale blue-lavenders. To darker purples or violets the stronger, clearer pinks of the peony often give a faded appearance.

In planning garden borders with thought for color effect, remember also that certain colors carry rather differently than might be expected and certain others do not carry at all. This must be guarded against, especially in varieties which are bicolors or blends of several tints. For example, the variety Rhein Nixe, which has white standards and falls of light violet bordered with white, is for all purposes a white iris in the garden. The violet color on the falls is too weak to carry far and the pure white is so conspicuous that it dominates the flower. This same effect is to be noticed in the varieties Gajus, Loreley, and Princess Victoria Louise, in all of which the luminous yellow standards eclipse the colored falls. Among blended varieties, Quaker Lady will serve as an example. This charming sort is a mixture of buff and pink and violet with distinct yellow in the throat. In garden mass it tells as a warm pinkish buff of rather dull color which does not carry well unless set off by a dark-green foliage background or by some variety of clear light color. Isoline and Merlin, which are blended varieties, show very clearly in garden masses as pink-toned irises, though on closer inspection they prove to be far from pink, even of such pinks as irises can boast.

For the person who is particularly interested in color effects, a study of the effect of light on color is of value in planning the garden, both in choosing its site and in deciding the location of surrounding plantings. As one must have sunlight in abundance to insure the health of his plants, the question is whether a strong shadow for part of the day or light moving shadows are more attractive.

Of the gardens known to the writer those in which there are long shadows cast by distant trees both in morning and evening, together with some light shade from small flowering trees during midday, have most beautiful light effects. The cool lights of morning and evening illuminate the delicate tissues of the petals in a very characteristic way, and this effect is lessened if there are trees of considerable size in the garden area to darken or obstruct this light. There should be some small trees, however, to break the furious heat of noon, a heat which destroys and fades the colors of all the light-hued flowers. For this purpose such trees as the flowering dogwood, Japanese styrax, flowering crab apples, cherries, and Chinese magnolias are of use, and climbing roses trained on pillars or posts make a pleasant break in the plantings.

If the garden is unavoidably in the shadow cast by a building or dense woods, plan the beds or borders so that varieties of clear colors are more in shadow than those of blended hues, as the latter are dependent upon sunlight for their best appearance.

There is a growing tendency to have gardens in which the planting is almost exclusively of irises. (Fig. 39.) This has great advantages for the irises themselves in that the entire area can be given a treatment especially adapted to them. Furthermore, the masses of flowers make as charming a sight as one can well imagine. There are certain objections to this plan, however, which should be faced. Even in climates where all the unusual irises can be grown, those that bloom in late winter and in late fall, there is but one season when the garden is literally ablaze with flowers, and that season is scarcely more than two months in duration even with the most careful planning and scheming. During the remaining season the foliage masses are rather dull and uninteresting, especially during July, when many kinds are ripening off the spring foliage and have not yet produced the autumn growth. These conditions may be accepted frankly and the garden treated as a "green garden" with adequate interest furnished by the masses of iris foliage, by the turf of paths which should be of ample width, and by the foliage of surrounding trees and shrubs. In the writer's garden the paths have been bordered by box, which gives definition to the areas and adds rich dark-green masses of texture sharply contrasting with the iris masses. French marigolds sown rather late are planted near the fronts of the borders in the spaces left bare by vanished clumps of narcissus foliage, and these, together with incidental bushes of lavender and common bluebeard (*Caryopteris incana* Miq.), make a secondary dis-

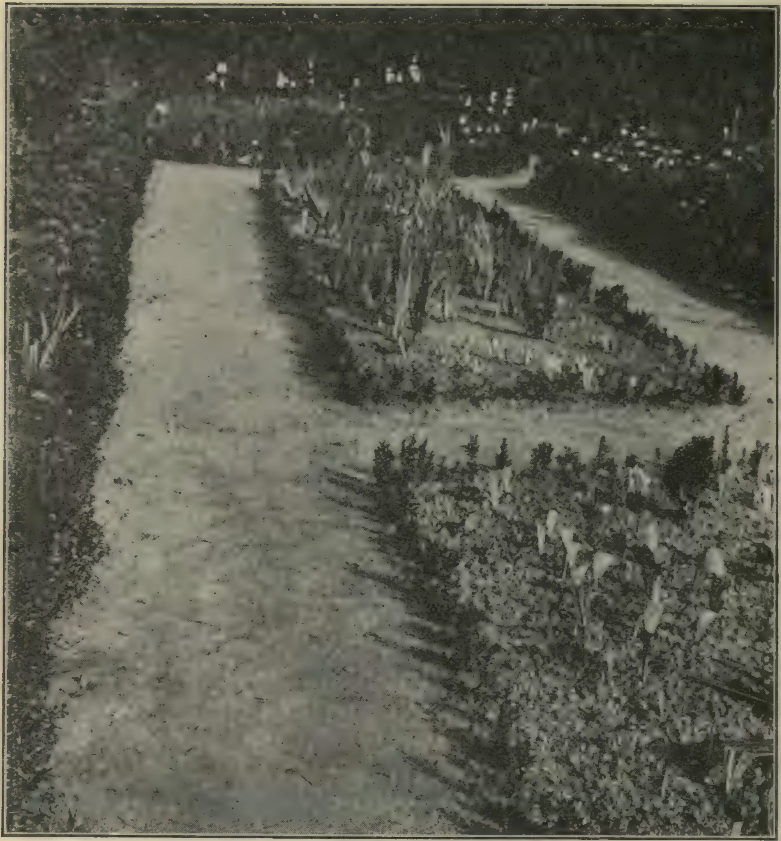

FIG. 39.—Iris garden, showing newly transplanted iris

play in late autumn. Sometimes chrysanthemums are added as isolated specimens for later effect, and the ever-increasing collection of summer-flowering hemerocallis has added other bits to the garden color. Other annuals that are useful in such gardens and which become established in the latitude of Washington, D. C., are cleome, petunia, and nigella, and the Chinese balsams and cosmos can be used, as their root run is slight, and if they are widely spaced no harm is done the irises.

When the designer wishes to use the iris with a view to securing even broader and more informal effects he must proceed with some caution in the choice of varieties.

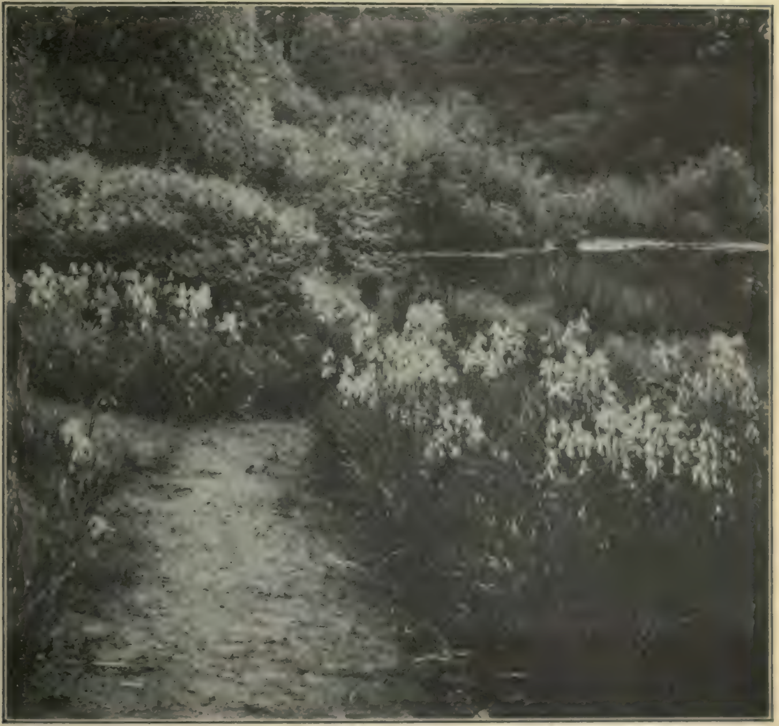

FIG. 40.—Siberian iris by the waterside

LANDSCAPE USES

Although irises are among the most permanent and enduring of perennials, they are not capable of caring for themselves indefinitely, especially if they are to furnish good annual bloom. The kinds chosen for this use should be those which are most like the wild species. This sort of planting is found commonly on the shores of ponds or streams in broad open meadows, whether alone or in conjunction with tree and shrub plantings. Here irises may be planted by the hundred or by the thousand with wonderful seasonal effect. (Fig. 40.)

For waterside plantings (fig. 41) none are better than the English flag (*Iris pseudacorus* L.) and the native blueflag (*Iris versicolor* L.). These are as nearly permanent as trees or shrubs, and once established they seed themselves indefinitely through the area. Both will succeed in actual marsh conditions and endure considerable freezing even in water-logged soils. The Japanese *Iris orientalis* is perhaps the nearest rival of these two species, as it is of almost equal endurance, but in very old clumps there is a tendency to stop flowering and to die from overcrowding. This is quickly noticeable when the plants are growing in shade. Almost equally strong are the Siberian irises. These are rather more dependent on moisture than the last named, but should be planted well above the water line in marshland. The Japanese irises themselves are not so valuable for extensive plantings of a semiwild nature. They are strictly horticultural varieties and need garden care. If this can be given there is no more gorgeous sight than a great mass of these huge irises in bloom. They require rich soil, full sun, an ample water supply, especially during the blooming season, and division of the plants every third or fourth year.

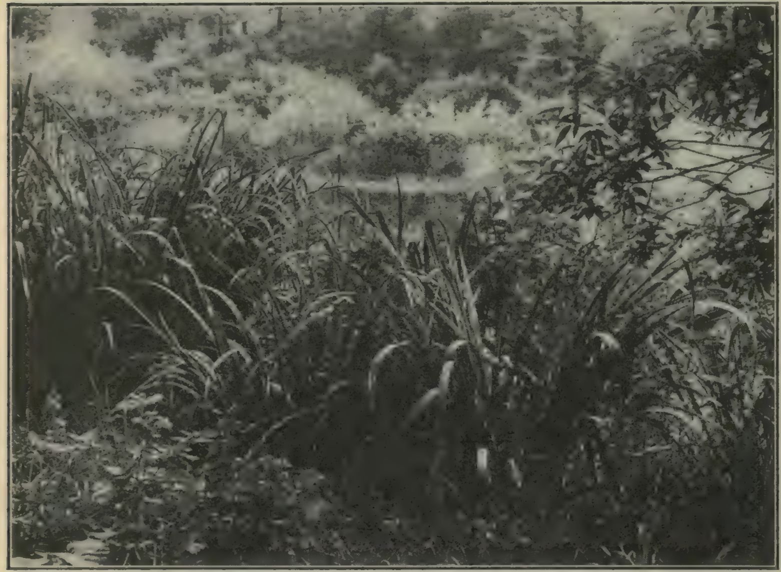

FIG. 41.—*Iris pseudacorus* by the waterside

The bearded irises have never been thoroughly examined and tested for use in naturalistic plantings. The permanence of the common blue form of *Iris germanica* in the dooryards of the country and the reported establishment of *Iris florentina* and *Iris albicans* in the South would point to their successful use through many regions. Gardeners who have had occasion to dump discarded varieties are often surprised at their flowering under most unfavorable circumstances. It is probable, however, that one should be guided in this matter by the geographical location of his planting and in the colder regions use only such varieties as have their origin in the species which are found to be native of the colder regions of Europe, leaving for the southern plantings those forms which have in them the blood of southern species. This will mean that for the northern planting the descendants of *Iris pallida* and *Iris variegata* will furnish the essential varieties, and in the South the derivatives of *Iris trojana* and *Iris mesopotamica* may be added.

In such plantings it is desirable to use single varieties in bold groups rather than mixtures of many colors. There is no particular lack of harmony in the use of mixed varieties unless by chance there comes the juxtaposition of strong yellow and cerise or magenta varieties, but there is a distinct gain in mass effect if there is a strong grouping of single varieties.

In choosing, it is well to remember that many of the pleasant refinements of tint and marking are lost in distinct views or may even become detrimental. For example, the variety Eldorado, which shows an interesting blend of dull gold and heliotrope close at hand, is a rather more dull affair at a hundred yards, and Parisiana, with its intricate veining and speckling of mauve on a white ground, appears as a dull-purple iris from a distance. Again, varieties like Princess Victoria Louise, with luminous standards and dull falls, carry chiefly as a small lemon-tinted flower. For this reason clear-colored sorts, like all the pallida varieties in their shades of lavender, mauve, and Chinese violet, the clear-yellow Flavescens, and some of the yellow variegatas, the sharp, clear bicolors, like Perfection and Nine Wells, all appear to greater advantage in masses than the other sorts. If the designer wishes to vary the tint within each group, to grade his lavenders from the almost white varieties, like Moonstone or Celeste, through all the intermediate steps to the dark purple of Parc de Neuilly, he adds greatly to the interest. The same sort of thing can be done in yellows, from the ivory white of Pancroft to the deep yellow of Mrs. Neubronner, or in the so-called pinks, from the tinted white of Wyomissing to the deep Chinese violets of Caprice or Edouard Michel or even on into the red purples of Opera and Archeveque.

To combine these contrasting color groups requires rather more skill. Usually the yellows are best used near the blue lavenders, avoiding the red lavenders unless the sharp contrast of pale yellow with deep mauves is desired. For the landscape sharp contrasts are less interesting than gentle gradations and even when purposely sought lose somewhat from the fact that the strong sunlight destroys some of the effect.

In arranging the plants within the groups and determining the shapes of the areas to be planted it will be found that masses which are longer than wide are of more attractive appearance than areas nearly equal in all their dimensions. In garden work the planting may be reduced at times to a single line of plants, which mature quickly into strong clumps with many flower stems. In landscape plantings of any considerable size such a scheme would appear too thin and feeble, and the designer must use his judgment in determining the width of the planting for his particular plan, remembering that the distance from which the planting must be viewed will make the apparent size of the area much smaller than is actually the case.

The colors in the planting areas may be arranged in solid blocks which extend across the tract, or they may be arranged in more or less diagonal groups. In the first case the colors would appear in gradation from one end of the planting to another, and in the second case there would appear a blending and mingling of the tints by the running together of the plantings. If thought is given to each of these arrangements variation to an almost endless extent can be made.

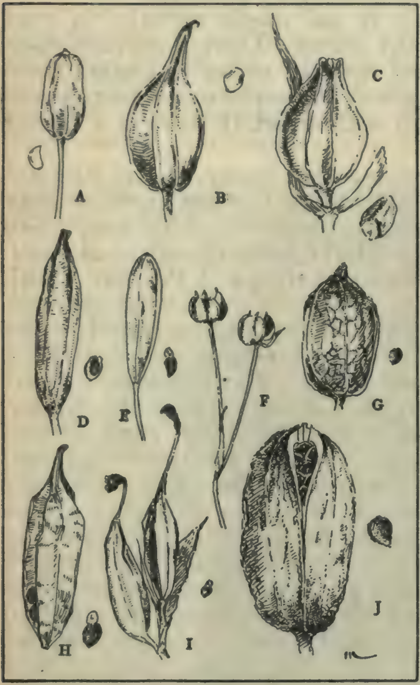

FIG. 42.—Iris seed pods and seeds: A, *Iris sibirica;* B, *I. spuria;* C, *I. foliosa;* D, *I. ensata;* E, *I. dichotoma;* F, *I. gracilipes;* G, *I. tectorum;* H, *I. korolkowi;* I, *I. arenaria;* J, *I. trojana*

PROPAGATION

Although mention has been made from time to time of the propagation of the various sorts as they were described, a review of the general method should be made.

PRODUCTION FROM SEEDS

Nearly all wild irises produce seeds (fig. 42) with considerable freedom, and this forms one of the most satisfactory ways of obtaining the species, many of which are collected and transported with difficulty because of their scanty root systems or slender rhizomes, which perish in transit.

In the neighborhood of Washington, D. C., the seeds of irises commence to ripen during the month of July, and except in the case of the late-flowering Japanese irises and the August blooming *Iris dichotoma* the seeds of nearly all are ripe before the end of August.

Without exception the best time for planting iris seeds is immediately after their harvest. When the seed pods begin to turn yellow they should be watched carefully. Those that dehisce at the apex may be left on the plant until they commence to open, but those which dehisce laterally, as in *Iris arenaria* or *Iris korolkowi*, should be gathered before, as all the seeds are soon lost after the pod opens. The seed should be removed from the pod and left to dry off for several days. It should then be planted.

The practice of planting will depend somewhat upon the species. The Siberian irises, the English and American flag irises, the Japanese irises, and most of the Spuria group of irises germinate the spring following their planting. The same is true of most of the bearded irises both in self-set or hybrid seed if the planting is immediate. Members of the California group of irises have germinated very irregularly in the experience of the writer, as have the few seeds of Regelia irises he has handled. The same is said to be true of the seeds of Oncocyclus species and varieties. If iris seed is not sown promptly the germination appears to become irregular and is at times greatly delayed, all of which points to the value of immediate planting. The writer has planted both in open ground and in pots kept in a frame, and aside from a possible convenience in handling has found no advantage in the latter method.

As the seeds of nearly all sorts have a hard shell, the freezing and thawing of winter are a distinct advantage and should not be guarded against unless there is danger of the seeds being heaved out of the soil.

The seeds should be covered about twice their depth and may be planted very thickly (fig. 43.). As soon as they can be handled after germination the young plants should be pricked out into the positions where they are to remain until flowering. It is very important that they should be transplanted promptly (fig. 44) and that they grow quickly, because with unimpeded growth they usually reach a sufficient size to blossom the year following germination in the case of the bearded irises. The beardless species commonly require two years to reach flowering size, and the Regelia, Oncocyclus, and bulbous irises a still longer time.

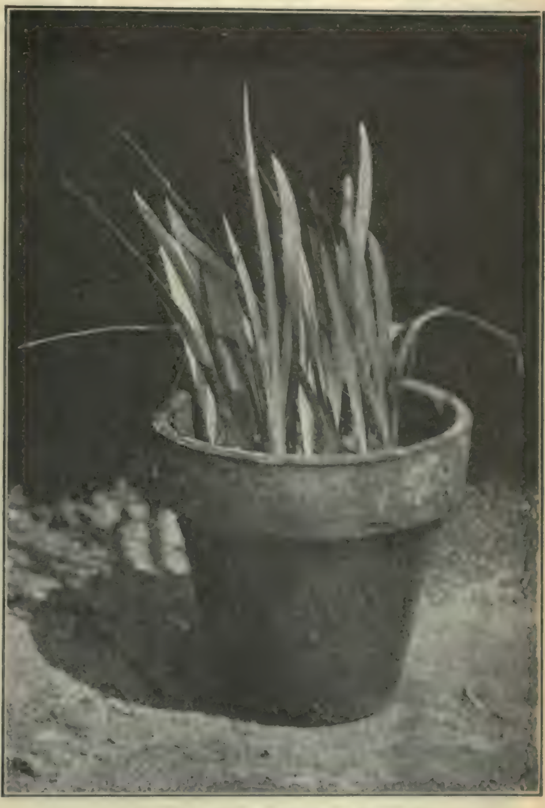

FIG. 43.— Iris seedlings in pot

All the species are truly reproduced from seed and show only such variations of color, form, and stature as one might expect to find throughout the range of the plant in nature.

Garden varieties for the most part do not reproduce themselves from seed. The Siberian irises, which are usually self-pollinated, commonly reproduce their color variations dependably. The bearded irises vary conspicuously even when fertilized with their own pollen. This is the inevitable result of their mixed ancestry.

Owing to the revival of interest in the bearded iris, many people are now raising seedling irises of this kind. The writer has raised hundreds, possibly thousands, and of them all relatively few have been distinct and desirable. After the first few years of experimentation, however, the seedlings in the strain developed showed a markedly high quality, and if the grower wishes to raise flowers only for his own use this becomes a fascinating way of securing distinct and beautiful sorts.

DIVISION OF THE ROOTS

Nearly all irises can be increased by division of the roots. The bulbous sorts divide, and the small bulbs which form about the base may be removed and grown to flowering size. The sorts which grow from rhizomes are more easily managed. An iris rhizome grows along with annual growths until it produces its terminal flower stalk. In order to carry on the growth at least one lateral branch is produced on either side of the bloom stalk, and these grow on until they in turn flower and produce branches. Figure 45 explains this method of growth diagrammatically and Figure 46 illustrates a root marked for division, which shows that growth is actually less regular.

FIG. 44.—Young seedlings of Pogoniris

When the propagator takes such a root he cuts it as indicated in Figure 47. The terminal portions will continue immediate growth from the already developed leaf shoots. The remaining portions will produce growths from various dormant buds along the rhizome.

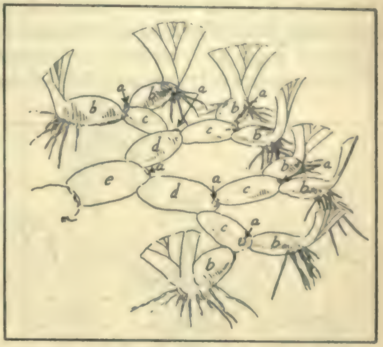

FIG. 45.—Diagram showing the growth of a rhizome: *a*, Scars of bloom stalks; *b*, current year's growth; *c*, preceding year's growth; *d*, growth of second year preceding; *e*, growth of third year preceding.

Because a rhizome is morphologically a stem (fig. 48), it bears dormant buds which could produce new stem growth at the base of every leaf. Theoretically, therefore, if the rhizome were cut into small sections, each with a dormant bud, there would be a plant resulting from each portion. In actual practice this is not altogether successful, and such extensive propagation would so weaken the strength of the variety that it would show a marked decline in constitutional vigor.

For garden purposes, therefore, a moderate rate of division should be practiced, and the operation should not be repeated more often than is required, usually every third year.

In plants where the rhizomes are more slender or where they are crowded into close masses, as among the apogons, the parts are too small to make a division into sections practicable. In such cases the clumps are best lifted, the earth shaken away, and the mass divided with a sharp spade or heavy knife.

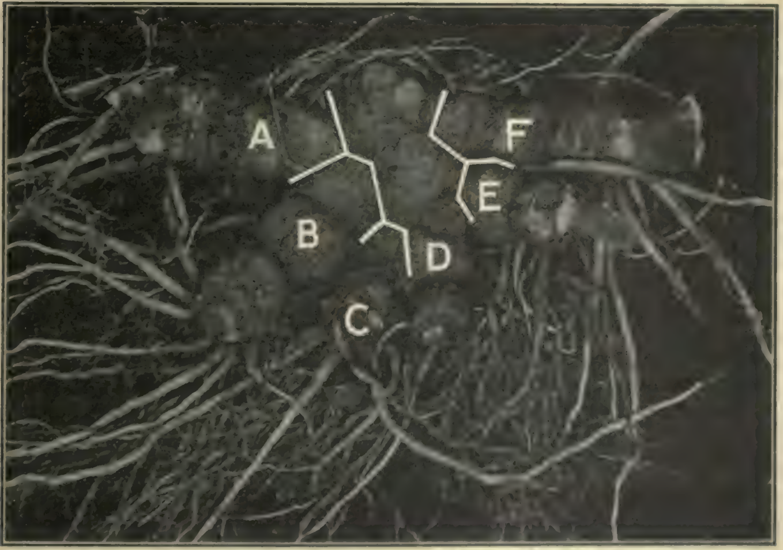

FIG. 46.—An iris rhizome marked for division

The bearded irises should be divided immediately after flowering, in order that the new pieces may establish themselves in time to produce the embryonic flowers for the next season before frost comes. The beardless irises may be divided at the same time; but in the experience of the writer and of many others spring is a better time for both beardless and crested irises, and if they can be lifted and divided just as growth commences the success is even greater. In all cases where irises are lifted in leaf, the foliage should be cut back to reduce the evaporating surface (fig. 48).

It should be remembered that when one is transplanting any plant in his own garden and can move it quickly from one situation to another, it is possible to do rather more as one pleases than when receiving plants from a nursery. The writer knows from actual experience that plants can be moved but not propagated at practically any time of year when the ground is not frozen. This requires extra care in watering, shading of tops, and mulching of roots, but except in unusual instances is not worth the effort involved.

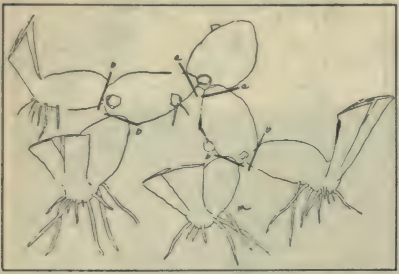

FIG. 47.—Diagram for division of rhizomes. For moderate division break apart at *a*, for full division break apart at *b*

HYBRIDIZATION

For the benefit of those who may wish to experiment with hybridization, Figure 49 shows diagrammatic flowers of irises of the Apogon and Pogoniris sections with the structural parts named. As the iris flower is built upon the plan of threes, examination will show three parts of each kind.

Cross-pollination is accomplished by the transfer of the pollen of one flower to the stigma of another. As the parts in the iris are large, the simplest practice is to carry the stamen of the desired male parent in the fingers and holding back the crest of the style branch with the fingers of the left hand scrape the pollen from the stamen held in the right hand upon the upper surface of the stigmatic lip in the flower to bear the seed. A little practice will bring expert results and rapid operation. A small pair of forceps is useful to pluck out the desired stamens in case the pollen-bearing flower must not be mutilated.

The best results appear to come from newly opened flowers fertilized with fresh pollen and from flowers pollinated before the heat of the day has become intense. Any moisture of dew or rain upon the stigmatic lip makes that flower quite useless for fertilization.

As the insects which visit the iris for its nectar very commonly, in the observation of the writer, go to the flower at the point of juncture of its segments with the perianth tube and drain the nectaries without disturbing the pollen-bearing stamen, there is relatively little insect pollination. For that reason no effort is made to bag the flowers or to prevent insect visits. The stamens of the seed-bearing flower are removed, however, before there is any pollen shed from them.

IRISES AT FLOWER SHOWS

Irises have come into such great popularity that they are one of the favorite flowers displayed either in exhibitions of spring flowers or in shows devoted entirely to them. The latter type of exhibition has been fostered by the American Iris Society, which through its patronage and publications has made itself felt in many communities. It is not within the scope of this bulletin to outline plans for holding of such exhibitions, as the routine of any exhibition is clearly detailed in Department Circular No. 62, "Horticultural Exhibitions and Garden Competitions."

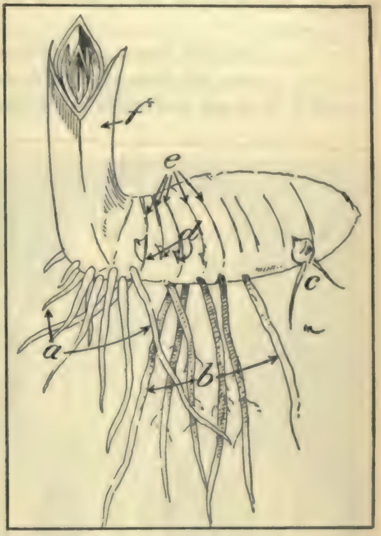

FIG. 48.—Rhizome of iris in autumn: *a*, New roots: *b*, roots formed in previous spring; *c*, shoot developing from bud in axil of leaf now dead; *d*, undeveloped buds in axils; *e*, scars of dead leaves; *f*, existing leaves cut back for transplanting

It is pertinent, however, to discuss briefly the characteristics which enter into the selection of flowers for exhibition, for these qualities should be the guide in selecting varieties for growth at home.

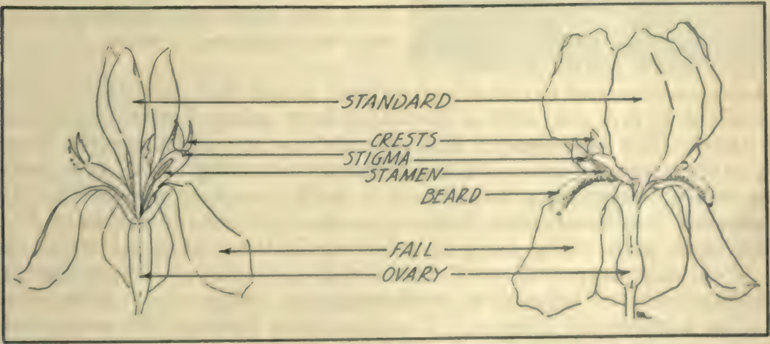

FIG. 49.—Diagram of parts of iris flower

There is no hard and fast schedule which can apply equally to all varieties aside from schemes of judging the general qualities of the flower. To these must be added the qualities of growth which determine the plant's garden value for most people. All plants do not grow with equal vigor or with equal effect. For example, Black Prince is a variety which is notorious for its lack of vigor, and Princess Victoria Louise is so vigorous that it becomes almost weedlike in its increase. To illustrate the other point, the variety Gajus may be chosen as an example of the varieties which make small rhizomes, so that a clump may be much divided and contain many blooming points and yet come within a small area. The Alcazar variety makes large rhizomes that bloom as freely as those of Gajus but which appear to be less floriferous because clumps of equal size produce fewer stalks of bloom. This apparent difference is somewhat offset in this case because Alcazar bears flowers several times larger than those of Gajus, but this is not true of every variety which grows from large rhizomes.

It has already been pointed out that varieties grow differently in various parts of the country, and if a variety is successful in one locality it is an indication rather than a guaranty of its success elsewhere. Every grower must experiment to a degree, and by comparing notes with his neighbors can find out what varieties are not suited to his locality.

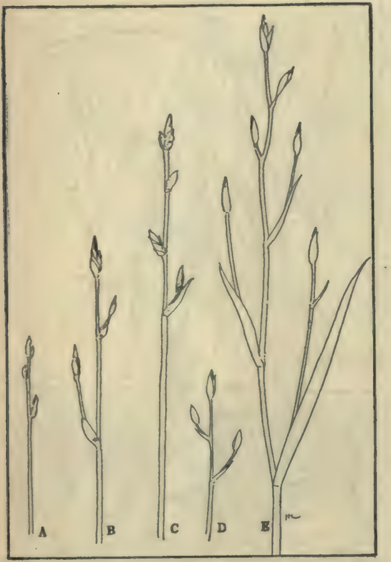

FIG. 50.—Types of stalks: A, *Iris cengialti*; B, *I. germanica*; C, *I. pallida*; D, *I. variegata*; E, *I. trojana*

Another point to be considered in examining the free-flowering qualities of a variety is the number of flowers which are borne upon a stalk. As the life of each bloom rarely exceeds three days at the maximum, it is obvious that a variety that bears but 6 flowers will appear much less floriferous than one which carries 14 blossoms. Figure 50 shows the type of flower stalk borne by various types of bearded irises, which is an indication of their floriferousness. It must be remembered that this is a factor which will vary with climate and location. Many disappointments have come because varieties have failed to repeat advertised performances in new localities. This has been particularly true of some imported varieties and is said to be true of some American introductions grown abroad.

In the writer's experience it has been noted that varieties in which the blood of *Iris cengialti* is dominant bear many flowers, an average of 5 to 8. The branches, if existent, are short, and the pretty flowers make an imposing array on the slender stems (fig. 51). *Iris pallida* commonly bears many flowers on a stalk, averaging 8 to 14. This character is also present in the plicata varieties, which may be no more than color variants of *Iris pallida* in their original forms, and it is carried over into such crossbred varieties as Afterglow and Quaker Lady. Varieties of pure variegata origin show great variation in number of blooms. Varieties like Honorabile carry many blooms, whereas those like Iris King, which is not a pure variegata, have relatively few flowers. Some wild forms of variegata from collected European plants show excessive floriferousness, which is accentuated by the shortness of the stalks bearing the small flowers.

Derivatives of *Iris macrantha* often carry few flowers. This is not always true, as Oriflamme averages 8 to 10 blossoms. Lord of June does not carry so many, rarely exceeding 6, and the writer has many seedlings with most beautiful flowers that never bear more than 5 blossoms to the stalk. Derivatives of *Iris trojana*, the other species which has fathered the modern large-flowered iris, carry for the most part many flowers to the stalk on widely branched stems which display the blooms ideally.

For landscape work, however, the best effects will be found from the varieties in which pallida and variegata blood predominates, whether mixed or pure, as these varieties bear their blossoms in profusion and produce the flower stalks so close together that a greater visual effect is obtained. If the planting is one of smaller area, to be viewed near at hand, there is no need for this limitation.

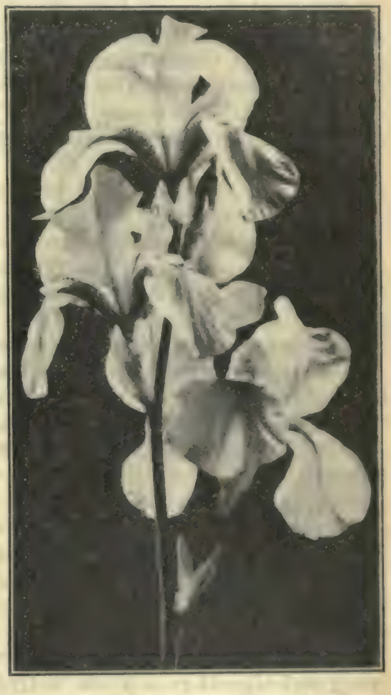

Fig. 51.—*Iris cengialti* var. Sappho

The selection of varieties will depend considerably upon personal taste. There are, however, various conventional points upon which there should be little difference of opinion.

When one examines a flower he commonly considers its size, color, substance, form, and scent. With the exception of the last, each of these factors must be considered with relation to others.

The size of a flower is one of the most dangerous features in discussion. There are persons who are always impressed by size, regardless of the presence or absence of other features. In the iris garden there is a proportion of visitors who always go to the plants of Lord of June and return to it from all others, regardless of the fact that it rarely produces a flower of sufficient substance to keep its form. Again, there are persons to whom a lack of size is a desirable feature and who find their chief pleasure in contemplating minute details. Probably there should be some middle ground. Certainly size or lack of it should never be the determining feature. The two features which should be present and considered always in connection with size are substance and form. Substance has to do with the thickness of the petals, with their firmness or lack of it. Obviously a plant with large petals must have a firmer substance than one with smaller petals in order to hold the shape of the flower. If anyone doubts the importance of this, let him examine a well-flowered clump of varieties, such as Kharput or Fontarabie, and notice the untidy and wilted appearance that comes from the collapsed standards. Compare these with the firm standards of such varieties as Koya or Dalmatica, and the resulting conviction will be inevitable.

If, then, we have a flower of sufficient substance to keep it in perfection, how much must its form contribute? This is relatively less important in connection with the matter of size and is more important as considered later in its major significance. At this point, however, it is enough to suggest that there must be a proper relation between the development of the parts so that top-heavy shapes do not appear. A flower in which the standards are overdeveloped has a form that is balloonlike and ungraceful in the extreme. This is especially apparent in varieties where the falls clasp the stem and appear smaller than they are. Tamerlan is a typical example.

Substance, as said before, has to do with the thickness or thinness of the petal tissue. In iris flowers the fault usually lies in the thinness rather than thickness of petals, and the importance of adequate thickness has been remarked. With substance is commonly considered the texture of the petal surface. This has to do with the smoothness of the tissue. Nearly all varieties have texture of satin smoothness, but occasionally there is a variety with a rough surface. The intermediate Gerda shows considerable roughness of surface, and the variety Zua has a texture so craped and cockled that it becomes the distinguishing feature of the flower.

Fragrance is commonly present in most varieties, but is conspicuous in the pallida irises and even more so among the progeny of *Iris trojana.* The varieties Caterina and Mandalay are exquisitely scented. Fragrance is certainly an addition to any flower, but the lack of it can hardly be considered a serious fault.

Color is a difficult matter to describe. On general principles careful judges require that self-colored varieties should have clear distinct colors, blended varieties the combination of harmonious tints, and bicolor varieties colors that contrast pleasantly. But quite aside from this, there can be found a champion for nearly every hue and tint alone and in combination, and it is true that even the most curious and dull can be made to look well if they are combined with the proper colors and shown in the proper lights.

The remaining factor, form, is difficult to consider. It deals with the relation of the parts of the flower one to another and their arrangement and carriage in the flower as a whole.

The standards are variously arranged in the flower, in one extreme lying flat almost in a plane with the falls, as in the varieties Clematis and Japanesque; cupped, as in Oriflamme or Merlin; tips adpressed, as often in Madame Chereau; domed, as in Kharput; overarched, as in Lord of June; and conic, as in Monsignor or Empire. The personal preference of the writer is always for blooms with the overarched or conic arrangement of the standards, though there are some cupped flowers that are very attractive.

The falls may be held horizontally, as in some of the variegatas; with a pleasant flare, as in Iris King; straight hanging, as in Isoline or Alcazar; and reflexed, as in Tamerlan.

Aside from the carriage of these parts as they are described, it is important to note how each segment appears in itself. There is a strong group of veins through the center of each, and there is a tendency for the segment to curve away from this. Those which are smooth or curve slightly usually present the best appearance. At times, as in varieties like Madame Chereau, the revolute character of the petal together with the ruffled edge gives a light and airy appearance that is delicate and pleasing. This is rarely true if it appears in the lower segments, and varieties like Isoline and Tamerlan suffer from it most decidedly.

Again there occurs in some sorts a pinching of the fall just below the end of the beard that gives a most unpleasant appearance. Sometimes this is present in Baronet, and it certainly shows in the photographs of such distinguished varieties as E. H. Jenkins and Phyllis Bliss.

After a careful study of flower forms in all the iris varieties one develops a sense of fitness which governs his judgment, producing no fixed image of what the ideal flower should be but rather giving a somewhat flexible standard by which nearly all varieties can be measured. Soon all will be found embodied in one or two commercial sorts, which can then become the standards of comparison for the individual.

DISEASES AND INSECT PESTS

DISEASES

The culture of the iris presents little difficulty to the gardener in the matter of diseases and insect pests.

The least serious of all are the species of rust and of leaf-spot that are found. The writer has had but little experience with rust (*Puccinia iridis* (DC.)Wallr.) and has been unable to discover any other garden where it has been a serious matter. It occurs on the leaves as small pustules of dull rust color and makes a very untidy appearance. No effort has been made to eradicate it, and the prescribed treatment of a spray of liver of sulphur is repeated on the authority noted.[1]

Leaf-spot (*Heterosporium gracile* Saccardo) is much more prevalent than rust in gardens known to the writer, and in the climate of Washington, D. C., makes its worst outbreak just after the time of flowering, so that, together with the natural dying of the foliage, the appearance of the plants becomes very unsightly. This is especially notable in the derivatives of *Iris trojana* and *Iris mesopotamica*, which tend to lose their leaves during summer when in the best of health. The new growths produced in autumn rarely show the blotches, and the spring growth is not disfigured until after the blooming season.

The writer removes and burns all the diseased leaves as soon as noted and in the case of bad outbreaks cuts off the upper portions of the leaves, as is done at transplanting time. This answers rather well, as the outbreak is confined commonly to the upper part of the leaves. A spray of ammoniacal copper carbonate is useful in checking the spread of the disease.

Iris root-rot, which is the result of a bacterium (*Pseudomonas iridis* Van Hall), is a serious difficulty in some gardens. This makes itself known by the falling of the fans of foliage at the crown. Upon examination they will be found soft and coming off the plant easily. The rhizome itself is commonly decayed, leaving a custardlike mass which gives off an offensive and unmistakable odor. The plant should be lifted, all the soft portions cut away into firm tissue, and the rhizome treated with some disinfectant. The writer prefers to leave the rhizome exposed to the sunlight for a day or two and to replant in a fresh location, but as an additional precaution he has used very dilute solutions of potassium permanganate, which appear to burn out all infected matter. If the plants can be kept growing in full sunlight for at least one season after the attack, there is not much chance of a reappearance of the disease unless by a reinfecting from without. The disease seems most virulent in the varieties with large rhizomes, especially the trojana and mesopotamica derivatives.

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[1] Dykes, W. R. The genus Iris, p. 16. Cambridge (Eng.), 16 p. 1913.

INSECT PESTS[2]

The iris borer (*Macronoctua onusta* Grote; fig. 52) is the most serious of the various insects which are known to attack irises. Recent records in the Bureau of Entomology indicate that it occurs in New York, Pennsylvania, Ohio, Maine, Connecticut, Illinois, and Iowa, while garden records add Massachusetts, Maryland, and California to this list. The moth apparently lays its eggs in the fall near or on the basal leaves. According to literature, the overwintering eggs hatch in the spring, in April in the neighborhood of Washington, D. C., and the young larvæ eat their way downward inside of the leaves toward the rhizome, where they continue feeding in the older woody portions (fig. 53), sometimes eating out the growing point and destroying the plant. In the early stages their presence may be recognized by the bleeding of the plant, which shows between the folds of the leaves as a wet stain. Later in the season the leaves become stunted and darkened. By late summer, if the plants are dug, the actual burrow can be found in the woody rhizome.

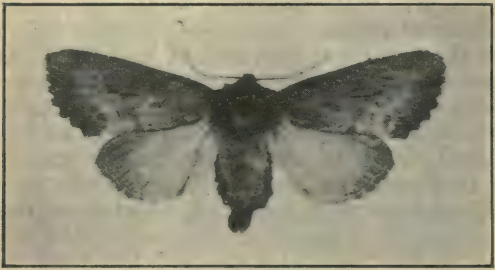

FIG. 52.—Adult moth of the iris borer

It sometimes happens that the bacterial rot already described occurs with the attack of the borer, making the destruction of the plant more complete. Reports of this character have come chiefly from nurseries where irises are grown in field culture.

By July or August the developing larvæ will reach maturity and are then about an inch and a half long, whitish with a pronounced pinkish tinge above the spiracles. Pupation takes place in the soil near the base of the plants usually in August or September, depending on the locality. The pupa is shiny chestnut-brown in color. The adult moth is short lived, and the female lays her eggs soon after emergence.

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[2] This statement has been approved by C. A. Weigel, Bureau of Entomology, United States Department of Agriculture.

While many varieties and species of iris seem susceptible to attack, the writer of this bulletin has observed such species as *Iris chrysographes*, *Iris bulleyana*, and *Iris wilsoni* to be seriously injured by it, with complete loss in some cases. *Iris sibirica* is often seriously crippled, and occasionally *Iris pseudacorus* is demolished, but the Pogoniris sorts rarely succumb to it, nor do the irises related to *Iris foliosa*.

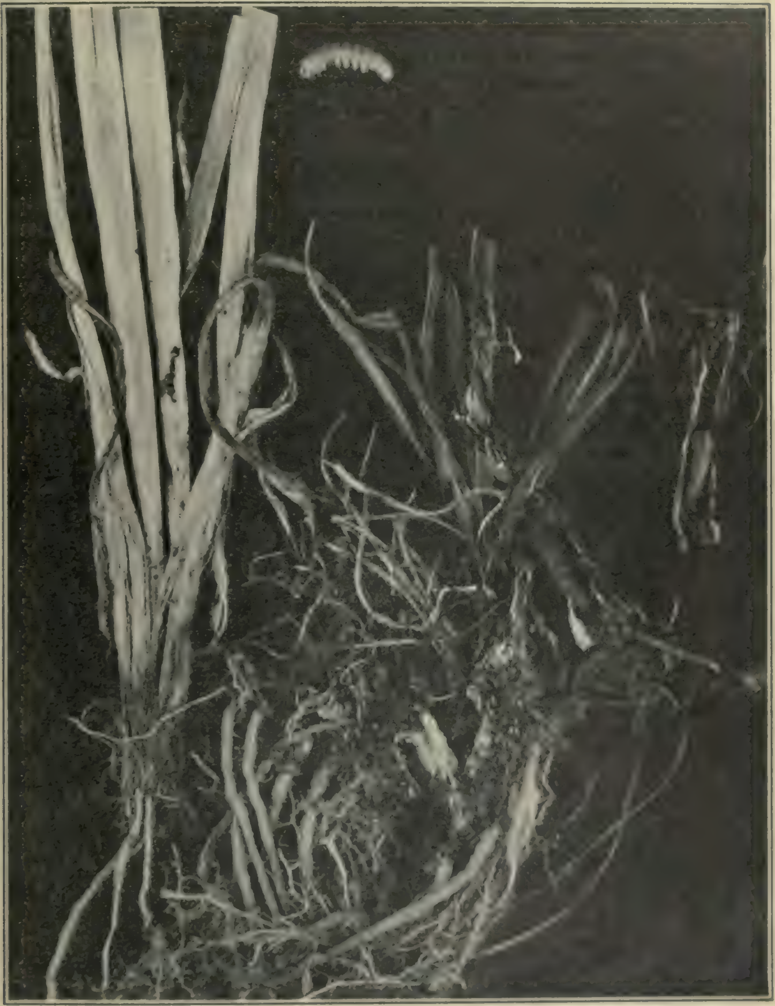

FIG. 53.—Iris borers at work

Control.—In small gardens, especially in plantings of very expensive varieties, many plants may be saved from serious injury by the laborious method of hand picking. If the plants are examined as they push into active growth and all leaves which show the characteristic wound are squeezed firmly between the thumb and fore-finger, commencing at the ground and pulling upward, the small larvæ are killed and the growth of the plant is not seriously affected. In large plantations, such as nurseries, this method is scarcely practicable. Here infested plants should be lifted in July and August, examined carefully, and all unsound portions cut out and destroyed, preferably by burning, together with the larvæ present. To prevent subsequent infection by any disease the cut surfaces of the rhizome should then be treated as suggested under iris root-rot. Late fall burning of the plantations is suggested by some growers, but this practice is open to objection, since injury to the rhizomes is likely to follow in some cases. Cutting off all particles of leafage as close to the ground as possible and then raking and burning them in order to get rid of the eggs is suggested by some growers. This practice removes the source of infestation for the next year but is hard on the vigor of the plants.

Cutworms cause great trouble in seedling beds. When such conditions exist scatter about the infested beds a poison bran mash prepared according to the following formula:

¼ pound white arsenic.
1 peck dry bran.
1 pint sirup of molasses.
4 to 6 quarts water.

The white arsenic and dry bran are first mixed thoroughly in a container. In another vessel stir a pint of cheap molasses or sirup into 4 to 6 quarts of water. Then prepare a mash by slowly adding the mixture of sirup and water to the poisoned bran. Allow it to stand for several hours, to permit the bran to take up the arsenic. Scatter thinly over the surface of the soil after sundown.

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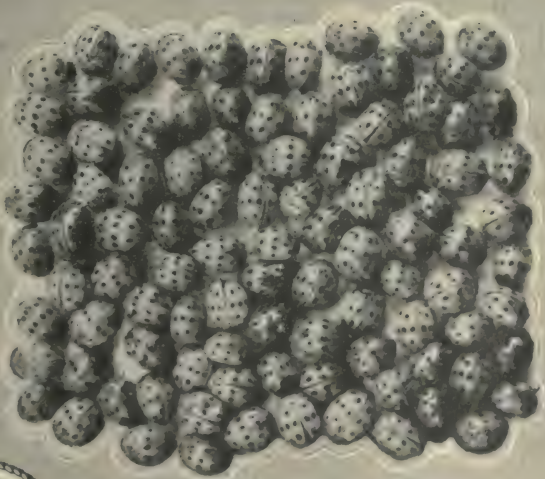
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1407

The MEXICAN BEAN BEETLE IN THE EAST



THE Mexican bean beetle in its range of distribution is the most serious insect enemy of beans in the United States. In the Southeast it was first found in Alabama in 1920, and now infests large areas in Alabama, Georgia, Tennessee, and Kentucky, and smaller areas in the Carolinas, Virginia, Mississippi, and Ohio. It is spreading northward rapidly and may soon extend its range over most of the Eastern States.

The adult is a copper-colored beetle, bearing eight black spots on each wing cover, and is about one-fourth of an inch long. The larva is orange colored and is frequently described as "fuzzy."

This insect feeds on the plants of all kinds of table beans, cowpeas, soy beans, beggarweed, and others of lesser importance. The principal injury is done to the foliage, but in cases of heavy infestation green pods also are destroyed.

Magnesium arsenate, used as a spray or as a dust, is the most promising insecticide. Calcium arsenate combined with hydrated lime is also useful.

Heavily infested fields should be plowed under as soon as the crop is off, and the grower should not plant more beans than can be properly treated.

Washington, D. C. May, 1924

THE MEXICAN BEAN BEETLE[1] IN THE EAST.

By NEALE F. HOWARD, *Entomologist, Truck-Crop Insect Investigations, Bureau of Entomology.*

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THE MOST DESTRUCTIVE INSECT TO GROWING BEANS.

THE MEXICAN BEAN BEETLE is the most serious insect enemy of beans in those parts of the United States which it inhabits. It has been long present in the Southwestern States, where it is as injurious to beans as the Colorado potato beetle has been to potatoes. In 1920, it was discovered at Birmingham and Blocton, Ala.

After becoming established over an area of about 4,500 square miles in northern Alabama, this pest destroyed practically all the beans in that section in 1921. It was injurious also to cowpeas, a hitherto unknown food plant, in some cases where this crop was growing in the vicinity of bean fields.

APPEARANCE OF INSECT AND NATURE OF DAMAGE.

The Mexican bean beetle is nearly hemispherical, one-fourth of an inch long and about one-fifth of an inch wide. Each of the brown wing covers bears eight black spots (fig. 4). The beetle closely resembles some of the native beneficial ladybirds, to which family of insects it belongs.

The larva is orange colored, varies in length from about one-twentieth of an inch when young to about one-third of an inch when full grown, and is covered with long, branched spines.

Injury by the larva and adult of the Mexican bean beetle to the bean plant is characteristic. The adult, feeding from below, eats ragged areas in the lower surface of the leaf, but often cuts through the upper surface, giving the foliage a lacelike appearance (fig. 2). The larvæ usually feed on the under surface of the leaf, leaving the upper surface intact. The lower tissue is cut away in narrow parallel sections about the length of the insect's body. Between these sections are narrow strips which are left untouched by the larva, resulting in a peculiar network not likely to be mistaken for the work of any other insect (fig. 3).

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[1] *Epilachna corrupta* Muls.; order Coleoptera, family Coccinellidae.

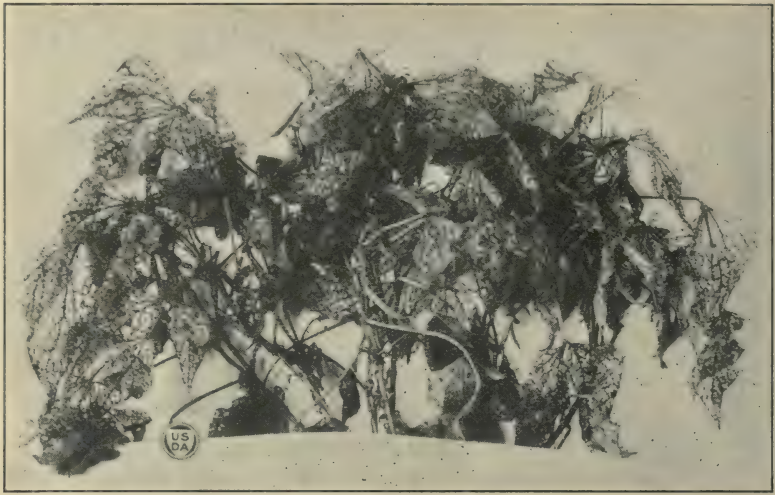

FIG. 1.—Bean plants in field, destroyed by Mexican bean beetle.

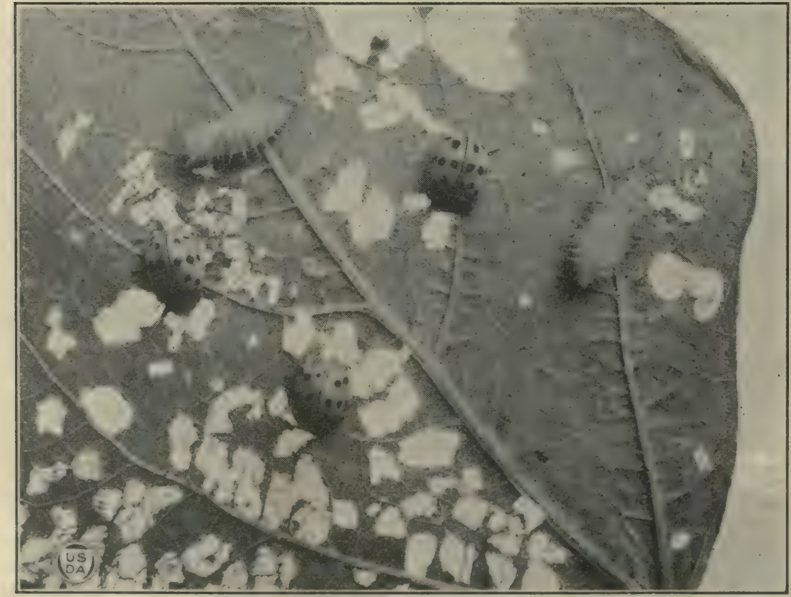

FIG. 2.—Adults and larvæ of Mexican bean beetle on under side of bean leaf, showing areas eaten by adults. Slightly enlarged.

All parts of the plant above the ground are fed upon by both beetle and larva. When the insects are numerous, the plant is destroyed and presents the appearance of having been completely dried out (fig. 1). After destroying the foliage, the insect may attack the pods, and even the stems. Injury to cowpeas and soy beans is similar, but attack on the stems and pods of these plants is very rare.

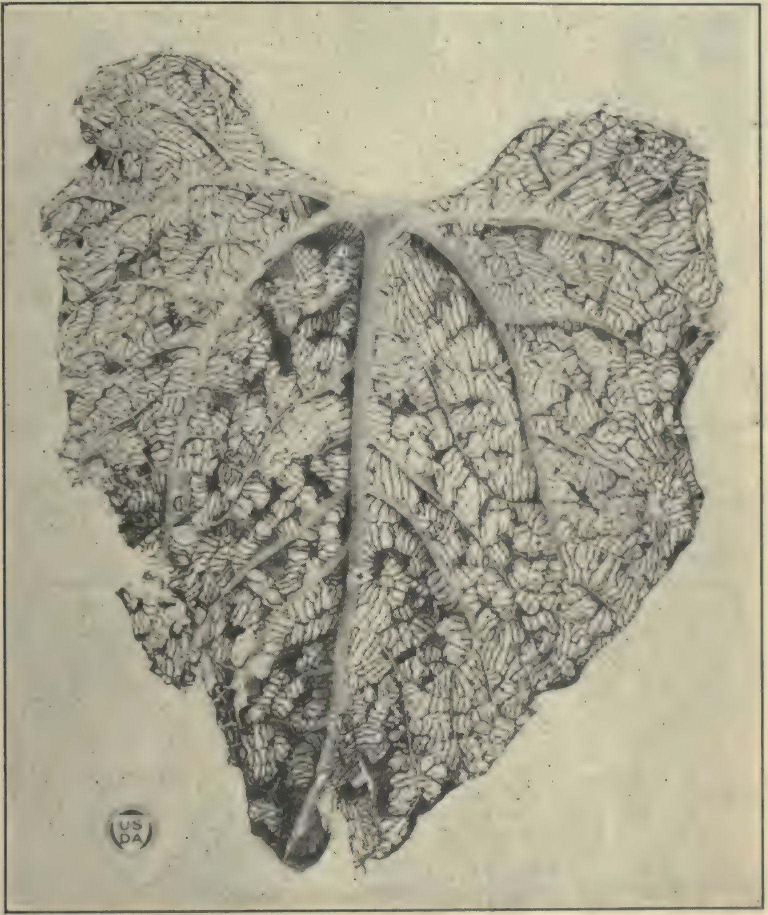

FIG. 3.—Feeding of larvæ of Mexican bean beetle on bean leaf. Slightly enlarged.

When the beetles are abundant, a bean crop may be completely destroyed in about four weeks, or before the pods are grown.

THE INSECT IN ITS DIFFERENT STAGES.

The eggs of the Mexican bean beetle are deposited in clusters of from 40 to 60 on the lower surface of a leaf. (Figure 4 illustrates the different stages of the insect.) The eggs are orange-yellow and when examined under a microscope are seen to be sculptured. The larva when first hatched is about one-twentieth of an inch long and after a few hours begins feeding on the under surface of the leaf close to the egg group. Each larva molts three times, becoming larger until it is full grown, when it is about one-third of an inch long and one-sixth wide. It then attaches itself to the under surface of a leaf, bean plant, weed, or other object near by, and becomes shorter but larger around the body, preparatory to pupation.

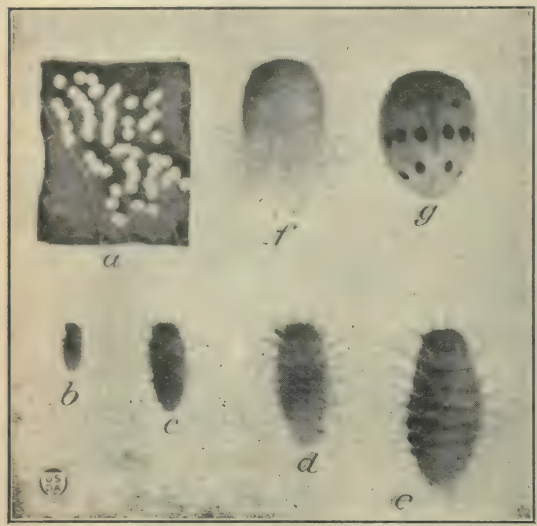

FIG. 4.—*a*, Eggs of Mexican bean beetle; *b*, *c*, *d*, *e*, first to fourth stages of larva; *f*, pupa; *g*, adult. Enlarged.

The pupa or inactive stage is orange colored, and is attached to the leaf by means of the fourth larval skin. When the adult emerges from the pupa, it is light-lemon colored and shows no markings, but the spots soon appear and it gradually becomes darker until after a week or 10 days it has become copper colored. Old beetles and those which have lived through the winter are darker in color and the spots are less distinct.

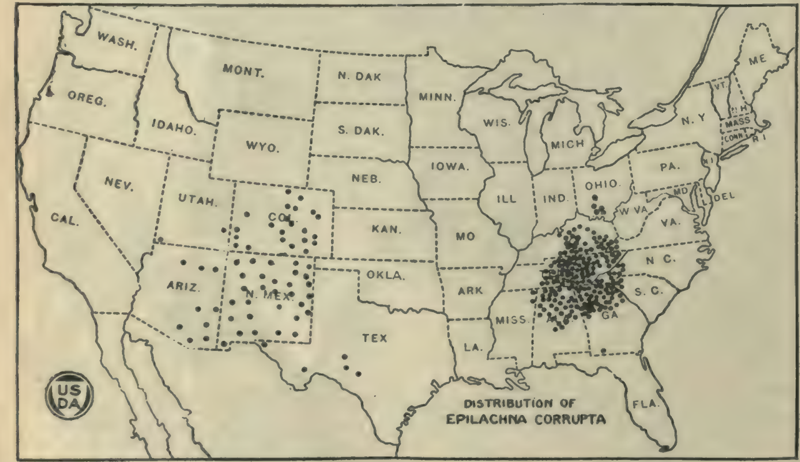

FIG. 5.—Map showing the known distribution of the Mexican bean beetle in the United States.

REGIONS IN WHICH THIS BEETLE IS FOUND.

The Mexican bean beetle originally came from Mexico. It has been known in the western part of the United States since about 1850.

In this region it is now known to exist in Arizona, New Mexico, western Texas, Colorado, and Utah.

In 1920 this pest was discovered in northern Alabama and by the fall of that year it had been found in portions of 13 counties. The next year it spread over an area about 10 times as large and was present in parts of 6 States. In 1922 it spread almost to the Ohio River in Kentucky, and into Virginia. It is now known to be present in all of these States, as well as in Mississippi and Ohio. (See fig. 5.) Undoubtedly in time it will extend its range over most of the hilly portions of the United States east of the Mississippi River.

This spread from the original point of infestation in northern Alabama has been accomplished mainly by flight, with the assistance of prevailing winds. The beetle is sluggish in its movements but is a comparatively strong flier, and during spring and late summer may fly many miles. Marked beetles have, within two days, been captured 5 miles from the point where liberated. During 1921 a spread of over 200 miles northward occurred, and in 1922 a spread of over 100 miles.

LIFE HISTORY AND HABITS.

In the latitude of Birmingham, Ala., the beetles begin to emerge from their winter quarters in late March or early April, just as the earliest garden beans are coming up; and by the middle of May most beetles have left their winter quarters, a very few, however, remaining there until about the first of June. On emerging from hibernation the beetles fly to near-by bean fields and the females deposit eggs after feeding for a few days.

Eggs laid in early spring require from 10 to 14 days to hatch. As the weather becomes warmer the eggs hatch in less time, until only 5 or 6 days are required. Larvæ that hatch in early spring develop rather slowly, and may require 5 weeks to complete their growth. Later in the season development of the larvæ requires an average of about 20 days. The pupal period during summer weather requires an average of about 7 days. Thus the total period of development from egg to adult requires an average of about 33 days in midsummer.

Within two weeks after emerging from the pupa the female beetle deposits eggs, and the life cycle is repeated. Some overwintered beetles may live until July, but the majority have perished by the first week in June. The insect reproduces so rapidly that by July or early August, under favorable conditions, it has become extremely abundant. Two generations are necessary for the maintenance of the insect in the Southeastern States, but a maximum of three or even four may occur. In the West and Southwest one generation is the rule, but in some sections a second generation occurs.

In August the beetles become restless and fly from field to field. At this time undoubtedly much of the spread into new territory takes place. Late in September and early in October the first beetles seek winter quarters, and others follow until about the first frost, in late October or early November, at which time practically all beetles have left the fields. All stages are present in the field from April until November, but eggs and larvæ usually become scarce during September and October.

HIBERNATION.

Only the adult lives through the winter. It hibernates preferably in woodlands near bean fields. It is semigregarious in habit. As many as 329 beetles have been found in one group covering less than 3 square feet, under pine needles and oak leaves on a well-drained, woodland hillside near cultivated bean fields (fig. 6). About 50 per cent hibernate singly, a few in and about the field or garden under rubbish and plant remains. The insects have been found hibernating three-fourths of a mile from the nearest field, but the majority occur within a quarter of a mile. In the West the beetle may fly many miles to hibernate. In the Southeastern States complete dormancy does not occur throughout the entire winter, since the beetles crawl about on warm days.

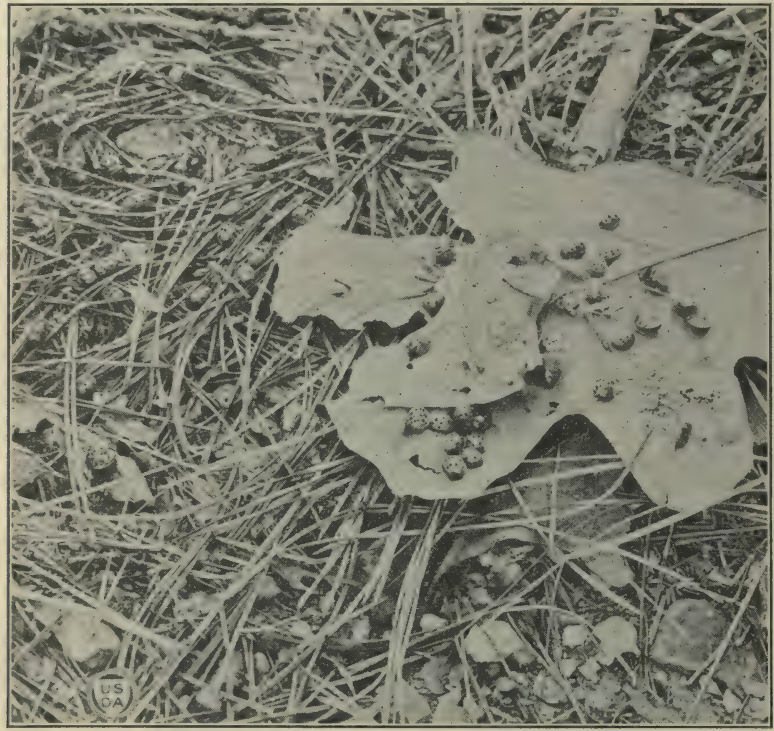

FIG. 6.—Mexican bean beetle hibernating under pine needles and leaves in woods.

FOOD PLANTS.

The Mexican bean beetle is primarily a bean pest, preferring the common bean and the lima bean to other plants. Its second choice is beggarweed,[2] or beggartick, which grows wild generally throughout the Southeastern States, and is cultivated for hay in some sections. The insect can reproduce successfully on cowpea and soy bean, and in some cases does injury to these crops. It also eats the hyacinth bean, adsuki bean, alfalfa, and sweet clover, but the last three are not desirable food plants and in many instances the insect dies when confined to them. When the insect is extremely abundant and when bean foliage has been destroyed, the beetle, and in some cases the larva, feeds on velvet bean, kudzu, crimson clover, white clover, corn, grasses, okra, eggplant, potato, squash, mung bean, and some weeds. Adults have also been observed feeding on Japan clover and downy milk pea.[3]

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[2] *Meibomia tortuosa* and *M. canescens.*

NATURAL AGENCIES OF CONTROL.

No internal parasite of the Mexican bean beetle had been recorded until 1922 when two native species of flies[4] were found to parasitize the insect in rare instances in northern Alabama.

A number of predacious insects feed on the eggs and young larvæ, and in some cases on the older larvæ, pupæ, and adults of the Mexican bean beetle. The most common of these in the Southeastern States is the spotted ladybird,[5] which feeds sparingly on the eggs and young larvæ. The "anchor bug"[6] in both immature and adult stages preys on larvæ, pupæ, and adults of this bean beetle. The spined soldier bug[7] attacks all stages. A few other bugs and a few beneficial ladybird beetles feed on different stages of the bean beetle, but are of little importance.

A tachina fly parasite[8] of this bean beetle is prevalent in some sections of Mexico, and efforts are being made to introduce the species into the United States.

Since the appearance of the Mexican bean beetle in the Southeast, this pest has varied as regards abundance. In general, the numbers of this insect decreased during 1922 and 1923. Soon after the insect reaches a new section, injury is usually extremely severe, and the second season after its arrival the bean crop is very likely to be destroyed.

In the West this pest varied from year to year in its injury to the bean crop, and it is probable that this will be true of the infestation in the East. No explanation for this can be made other than that weather conditions are probably the most important factors. Heavy rains during spring and summer seem to be detrimental to the insect, but extreme drought has not been observed to act as a material check so long as the insect's food plants do not become too dry.

The intense heat in the bright sunlight during heated periods in summer kills many larvæ and pupæ. When dry weather causes the bean leaves to curl, or when varieties of beans which have this habit are grown, many egg masses, larvæ, and pupæ are exposed to the sun and die. This has been observed only under conditions of extreme infestation, where insects were so abundant that they covered both the exposed and unexposed sides of bean plants and surrounding vegetation.

---

[3] *Galactia volubilis.*
[4] *Phorocera claripennis* Macq. and *Helicobia helicis* Towns.
[5] *Megilla maculata* DeG.
[6] *Stiretrus anchorago* Fab.
[7] *Podisus maculiventris* Say.
[8] *Paradexodes epilachnae* Ald.

CONTROL MEASURES.

SPRAYS.

The Mexican bean beetle can be successfully controlled by the use of certain arsenical poisons. Spraying has given best results for the past three seasons, 1921 to 1923. On account of the susceptibility of the bean plant to arsenical injury, arsenicals must be applied carefully. In the Southeastern States lead arsenate and zinc arsenite, which are reported to be useful in the West, have been found too injurious when tried on bean foliage to warrant their use under any conditions. Calcium arsenate, undiluted, is very injurious to bean foliage, but a high grade may be successfully used by adding lime as shown in the formula below. For the last three seasons magnesium arsenate has given best results because it does not "burn" foliage. One of the following sprays may be used effectively, at the rate of 90 to 100 gallons to an acre.

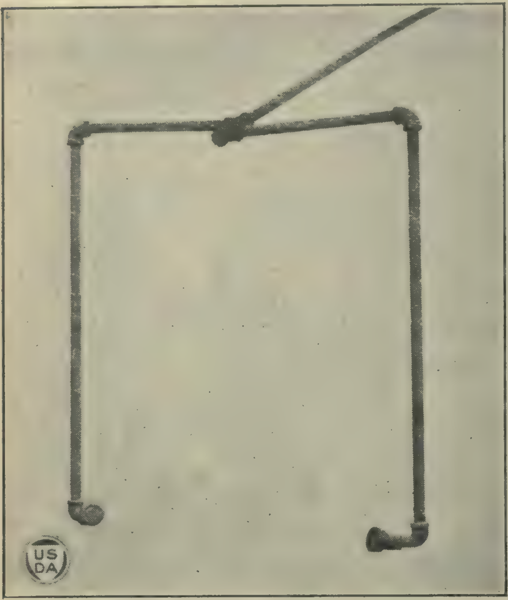

FIG. 7.—Proper arrangement of boom and nozzles for use with wheelbarrow or barrel sprayer.

MAGNESIUM ARSENATE SPRAY.

	For large areas.	For small areas.
Magnesium arsenate[9]	2 pounds.	1 ounce.
Water	100 gallons.	3 gallons.

CALCIUM ARSENATE SPRAY.

	For large areas.	For small areas.
Calcium arsenate[10]	1½ pounds.	¾ ounce.
Lime	3 pounds.	1½ ounces.
Water	100 gallons.	3 gallons.

DIRECTIONS FOR APPLYING THE SPRAY.

Since the Mexican bean beetle feeds on the under surfaces of the leaves, it is necessary to direct the spray to these parts. This can best be done by placing the nozzle, preferably a 45° angle nozzle, on a 90° elbow, at the end of the spray rod (fig. 7). Where two nozzles are used to the row, one nozzle should be turned slightly forward, so that the sprays will not meet too closely.

---

[9] Less than 0.5 per cent water-soluble arsenic pentoxide.

[10] Less than 0.2 per cent water-soluble arsenic pentoxide.

For gardens and very small patches a small compressed-air hand sprayer may be successfully used. (See fig. 8 for illustrations of sprayers.) For fields from half an acre to 2 acres in size, a barrel sprayer may be mounted on a wagon and a row sprayed from both sides by the arrangement of the nozzles on a boom, or a wheelbarrow sprayer may be mounted on a slide and one row at a time treated in a similar manner at walking speed. While neither of these types of machines is all that could be desired, a grower with less than 4 or 5 acres of beans can hardly afford to invest in a high-priced traction sprayer for this use alone. Growers who have 5 or more acres of beans should use a traction type of horse-drawn sprayer or a power sprayer which will spray at least two rows at once. On larger acreages a 4-row sprayer should be used.

The larger sprayers should be fitted with a boom so that three nozzles may be directed to each row. Excellent results can be obtained if the rows are straight and are planted at regular distances. At least 150 pounds pressure should be maintained.

DUSTS.

Although spraying with liquid poisons has given consistently better results against this bean beetle than dusting, the latter form of poison is becoming more popular year by year, and in the infested territory most growers prefer to apply insecticides to their beans in dust form. Also, where medium infestation exists, dusting gives good results. The following mixtures have been successfully applied, and the grower should choose the one best suited to his use:

MAGNESIUM ARSENATE DUST.

For very heavy infestation:

Magnesium arsenate[9]	1 part.
Hydrated lime	3 parts.

The rate of application is 10 to 12 pounds per acre.

For lighter infestation:

Magnesium arsenate[9]	1 part.
Hydrated lime	5 parts.

Rate of application, 12 to 15 pounds to the acre.

CALCIUM ARSENATE AND LIME DUST.

Calcium arsenate[10]	1 part.
Hydrated lime	9 parts.

Rate of application, 15 to 20 pounds per acre.

CALCIUM ARSENATE, SULPHUR, AND LIME DUST.

(Alabama Experiment Station Formula.)

Calcium arsenate[10]	1 part.
Fine dusting sulphur	1 part.
Hydrated lime	4 parts.

Rate of application, 12 to 15 pounds per acre.

APPLYING THE DUSTS.

The dust should be directed to the under surfaces of the leaves, covering as much foliage as possible. Enough of the mixture should

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[9] Less than 0.5 per cent water-soluble arsenic pentoxide.

[10] Less than 0.2 per cent water-soluble arsenic pentoxide.

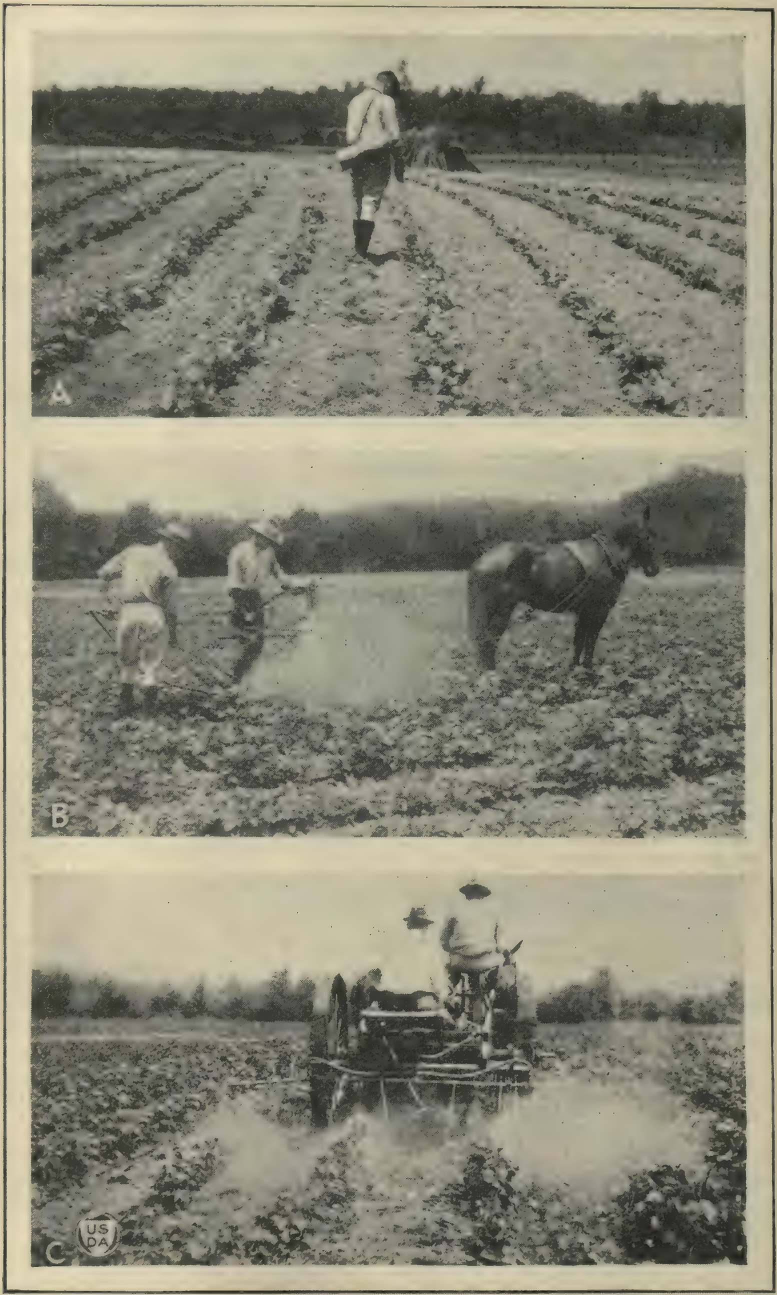

FIG. 8.—*a*, Spraying beans in small garden with compressed-air sprayer; *b*, spraying beans in small field with wheelbarrow sprayer mounted on slide and drawn by horse; *c*, spraying large field of beans with horse-drawn power sprayer.

be applied so that between 2 and 3 pounds of the arsenical in the dust is distributed on an acre of beans. Where a 1–9 calcium arsenate mixture is used, the grower may apply 15 to 20 pounds of the mixture to the acre of bush beans, and good results may be obtained under favorable conditions with only 15 pounds. Where the calcium arsenate, sulphur, and lime mixture is used, 12 to 15 pounds is sufficient for an acre. Where magnesium arsenate is employed, 10 to 12 pounds of the 1–3 mixture or 12 to 15 pounds of the 1–5 mixture to the acre is sufficient.

Dust mixtures may be prepared on the farm by placing the ingredients in a steel drum or barrel, which is then tightly closed and rolled about for a distance of 400 or 500 feet. At the same time it should be tipped on end at intervals of about 50 feet.

Dust should be applied with a good duster; never with a sack. For gardens and small patches of less than a fourth of an acre, hand dusters of the bellows or air-pump type are satisfactory. (See fig. 9 for illustrations of dusters.) On fields over a fourth of an acre in size and up to 5 acres, a larger machine should be used. A knapsack type of bellows duster with a spout attached to a flexible hose is effective. The dust can be directed to the under surfaces of the leaves with this machine. A fan type of duster may be used if the nozzle is turned sidewise so that the dust is directed under the leaves.

Where 4 or 5 acres of beans must be treated at one time, a horse-drawn type of 2-row duster is preferable where rapid treatment is desired. The nozzles, as with hand dusters, should be directed to the under surfaces of the leaves.

In the treatment of more than 5 acres of beans, a 2-horse, 4-row duster is the most effective. Best results have been obtained with a traction type of machine. For all dusting and spraying operations, the rows should be planted equal distances apart and should be straight. On good soil the average distance between rows should be 3 feet.

There is practically no danger of arsenical poisoning from consumption of treated beans, but they should be rinsed twice in clear water before marketing to assure absolute safety.

CULTURAL PRACTICES FAVORABLE FOR CONTROL.

Under Mexican bean beetle conditions every effort should be made to grow a vigorous, quickly maturing crop. The land should be well tilled and well fertilized, and an early-maturing variety of beans, suitable to the locality, should be grown. In cases of severe infestation, the control of this pest on pole beans is expensive because of the slow maturity of the crop and the greater number of insecticide applications necessary. Pole beans can not be easily treated with horse-drawn machinery.

The spring crop should be planted as early as approved practice in the locality will permit. In 1922, in Alabama, the early spring crop was not severely injured before it was harvested, but plantings made a month later were in most cases either destroyed or severely injured.

The fall crop should be planted as late as possible. The beetle does not reproduce so rapidly in late August and September as in spring and early summer.

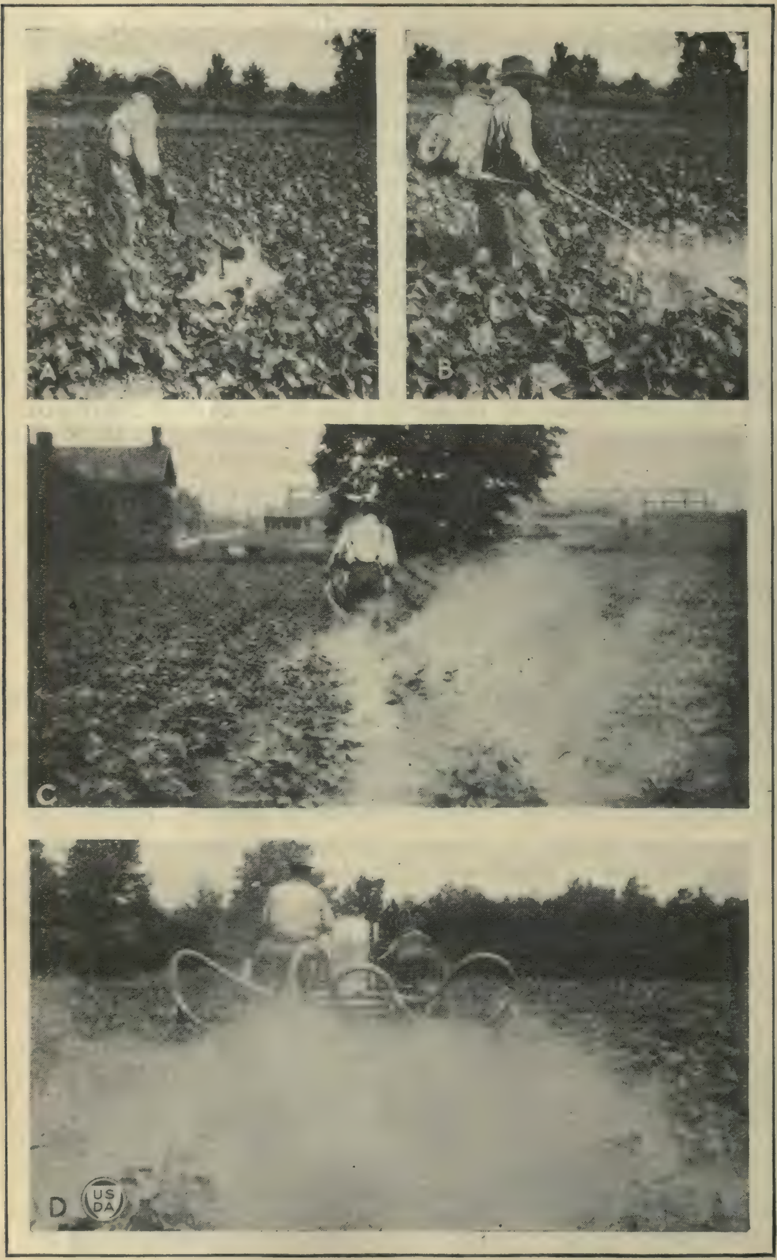

FIG. 9.—*a*, Small bellows duster suitable for home garden use; *b*, knapsack bellows type of duster for truck garden and small field use; *c*, 2-row horse-drawn duster in operation in 2-acre bean field; *d*, dusting beans for control of Mexican bean beetle with 4-row traction duster.

Where the bean beetle is extremely abundant, the plants should be plowed under as soon as the crop is picked. Thousands of eggs, larvæ, pupæ, and newly emerged adults may be destroyed in this manner. Covering the plant remains and insects with a few inches of soil with an ordinary plow is effective in destroying them.

SUMMARY OF CONTROL MEASURES.

Where the Mexican bean beetle thrives, growers must be prepared to practice remedial measures. Proper control measures may result in an excellent crop of beans alongside of untreated fields which are completely destroyed (fig. 10). Under bean beetle conditions, careful application of the following suggestions will largely protect the crop.

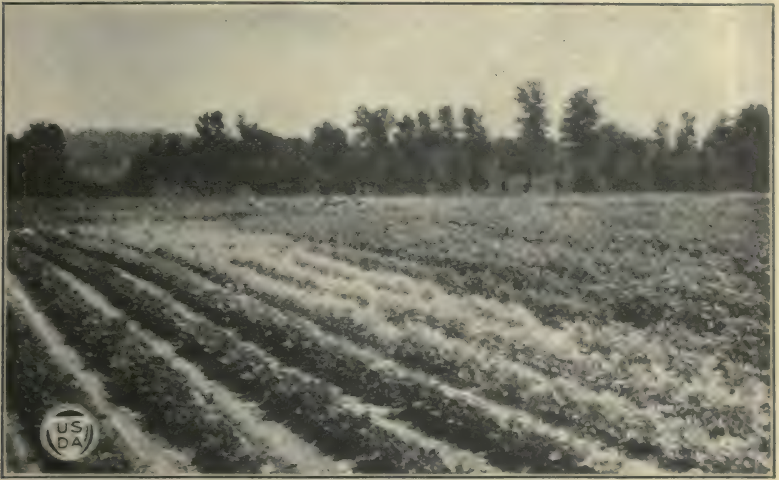

FIG. 10.—Untreated beans destroyed by Mexican bean beetle beside beans sprayed with magnesium arsenate.

Apply magnesium arsenate as a spray at the rate of about 2 pounds to the acre, using 2 pounds in 100 gallons of water, and directing the spray to the under surfaces of the bean leaves.

Begin spraying when the eggs of the bean beetle become numerous. This is usually when the plants begin to send out their first true leaves. Apply the spray from one to four times to a crop of bush beans, depending on the abundance of insects, and at intervals of a week or ten days.

When spraying can not be conveniently practiced, apply one of the following dust mixtures:

> Magnesium arsenate, diluted with from 3 to 5 parts of hydrated lime, using from 10 to 15 pounds of the mixture to the acre.
>
> Calcium arsenate, diluted with 9 parts of hydrated lime, using from 15 to 20 pounds of the mixture to the acre.
>
> Calcium arsenate, diluted with 1 part of fine dusting sulphur and 4 parts of hydrated lime, using from 12 to 15 pounds of the mixture to the acre.

Apply the dust when little or no wind is blowing.

Where the beetles are numerous, plant bush varieties of beans.

Plant only as many beans as can be properly treated.

In heavily infested areas, when a crop of green beans is removed, plow the plants under immediately.

Remove accumulations of leaves and plant remnants from woodlands near bean fields.

Do not burn over timberland. Burn over only waste places near bean fields.

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U. S. DEPARTMENT OF
AGRICULTURE
FARMERS' BULLETIN No. 1408

The HOUSE FLY AND HOW TO SUPPRESS IT

THE PRESENCE of flies is an indication of uncleanliness, insanitary conditions, and improper disposal of substances in which they breed. They are not only annoying; they are actually dangerous to health, because they may carry disease germs to exposed foods.

It is therefore important to know where and how they breed, and to apply such knowledge in combating them. This bulletin gives information on this subject. Besides giving directions for ridding the house of flies by the use of screens, fly papers, poisons, and flytraps, it lays especial emphasis on the explanation of methods of eliminating breeding places and preventing the breeding of flies.

This bulletin supersedes Farmers' Bulletin 851.

Washington, D. C. April, 1924

THE HOUSE FLY[1] AND HOW TO SUPPRESS IT.

By L. O. HOWARD, *Chief of the Bureau of Entomology*, and F. C. BISHOPP, *Entomologist.*

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KINDS OF FLIES FOUND IN HOUSES.

SEVERAL species of flies are found commonly in houses. Some of them so closely resemble the true house fly that it requires very careful observation to distinguish them from it.

One of these is the biting stable fly[2] (fig. 1). It occurs frequently in houses and differs from the house fly in the important particular that its mouth parts are formed for piercing the skin. This fly is so often mistaken for the house fly that most people think that the house fly can bite.

Another frequent visitant of houses, particularly in the spring and fall, is the cluster fly.[3] It is somewhat larger than the house fly, and is distinguished by its covering of fine yellowish hairs. Occasionally this fly occurs in houses in such numbers as to cause great annoyance. It gets its name of "cluster fly" from its habit of collecting in compact groups or clusters in protected corners during cold periods.

Several species of metallic greenish or bluish flies also are found occasionally in houses. These include a blue-bottle fly,[4] the black blowflies,[5] and the green-bottle (fig. 2) flies.[6] They breed in decaying animal matter.

---

[1] *Musca domestica* L.

[2] *Stomoxys calcitrans* L.

[3] *Pollenia rudis* Fab.

[4] *Calliphora erythrocephala* Meig.

[5] *Phormia regina* Meig. and *P. terrae-novae* Desv.

[6] *Lucilia caesar* L., *L. sericata* Meig., and other species of the genus.

There is still another species, smaller than any of those so far mentioned, which is sometimes called the "lesser house fly."[7] This insect is distinguished from the ordinary house fly by its paler and more pointed body. The male, which is commoner than the female, has large pale patches at the base of the abdomen, which are translucent when the fly is seen on the window pane. These little flies are not the young of the larger flies. Flies do not grow after the wings have once expanded and dried.

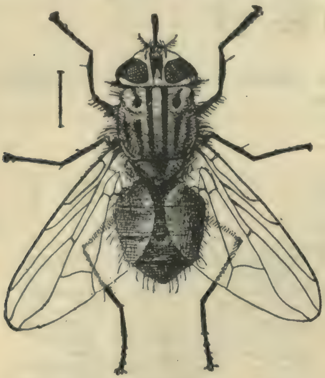

FIG. 1.—The stable fly. Much enlarged.

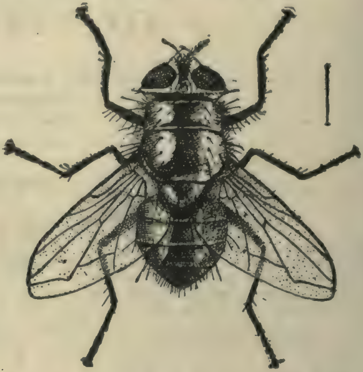

FIG. 2.—One of the green-bottle flies (*Lucilia caesar*). Much enlarged.

In late summer and autumn many specimens of a small fruit fly, known as the "vinegar fly,"[8] make their appearance, attracted by the odor of overripe fruit.

All of these species, however, are greatly dwarfed in numbers by the common house fly. In 1900 the senior author made collections of the flies in dining rooms in different parts of the country, and found that the true house fly made up 98.8 per cent of the whole number captured. The remainder comprised various species, including those mentioned above.

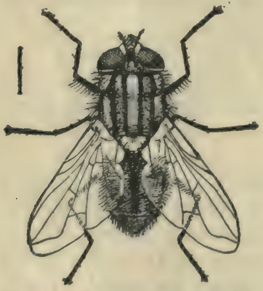

FIG. 3.—The true house fly. Enlarged.

WHERE THE TRUE HOUSE FLY LAYS ITS EGGS.

The true house fly (fig. 3), which is found in nearly all parts of the world, is a medium-sized fly with four black stripes on the back and a sharp elbow in one of the veins of the wings. The house fly can not bite, its mouth parts being spread out at the tip for sucking up liquid substances.

The eggs (figs. 4, 5) are laid upon horse manure. This substance seems to be its favorite larval food. It will breed also in human excrement, and because of this habit it is very dangerous to the health of human beings, carrying as it does the germs of intestinal diseases, such as typhoid fever and cholera, from the excreta to food supplies. It has also been found to breed freely in hog manure, in considerable numbers in chicken dung, and to some extent in cow manure. Indeed, it will lay its eggs on a great variety of decaying vegetable and animal materials, but of the flies that infest dwelling houses, both in cities and on farms, a vast proportion come from horse manure.

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[7] *Fannia canicularis* L.

[8] *Drosophila ampelophila* Loew.

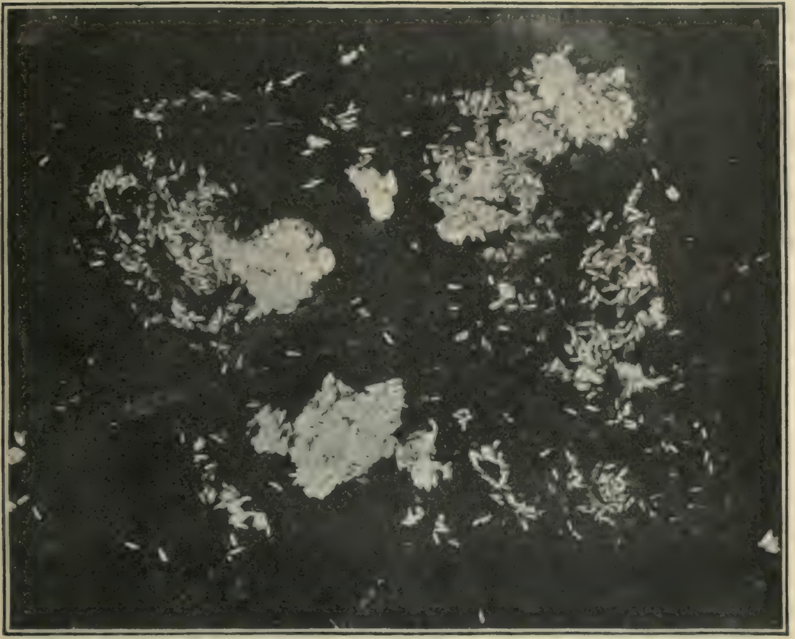

FIG. 4.—Eggs of the house fly. About natural size. (Newstead.)

It often happens, however, that this fly is very abundant in localities where little or no horse manure is found, and in such cases it breeds in other manure, such as chicken manure in backyard poultry lots, or in slops or fermenting vegetable material, such as spent hops, moist bran, ensilage, or rotting potatoes. Accumulations of organic material on the dumping grounds of towns and cities often produce flies in great numbers.

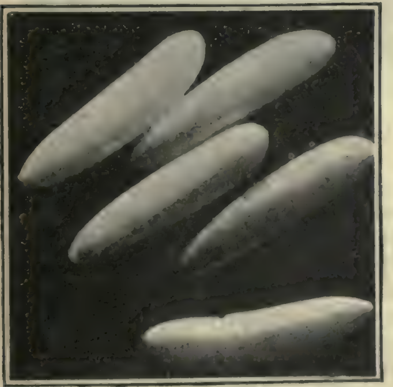

FIG. 5.—Eggs of the house fly. Highly magnified. (Newstead.)

The house fly begins laying eggs in from 2½ to 20 days after emerging, the time interval depending to a large extent upon temperature, humidity, and character and abundance of food. The number of eggs laid by an individual fly at one time ranges from 120 to 159 and a single female will usually lay two and sometimes four such batches. Dunn has recently reported that in Panama a fly may deposit as many as 2,367 eggs in 21 batches, and sometimes an interval of only 36 hours may occur between the deposition of large batches of eggs. The enormous numbers in which the insects occur are thus plainly accounted for, especially when the abundance and universal occurrence of appropriate larval food is considered. The eggs are deposited below the surface in the cracks and interstices of the manure, several females usually depositing in one spot, so that the eggs commonly are found in large clusters (fig. 4) in selected places near the top of the pile, where a high degree of heat is maintained by the fermentation below. The second batch of eggs is laid from 8 to 10 days after the first. The eggs usually hatch in less than 24 hours. Under the most favorable conditions of temperature and moisture the egg state may last hardly more than 8 hours. The maggots which issue from the eggs are very small and transparent. They grow rapidly, completing the growth of the larva stage in three days under the most favorable conditions, although this stage usually lasts from 4 to 7 days. The larval period may be prolonged greatly by low temperature or by dryness or scarcity of the larval food. As the larvæ (fig. 6) attain full size they gradually assume a creamy white color. A few hours before pupation they become very restless and migrate from their feeding ground in search of a favorable place in which to pass the pupa stage. They will often congregate at the edges of manure piles near the ground or burrow into the soil beneath, or they may crawl considerable distances away from the pile to pupate in the ground or in loose material under the edges of stones, boards, etc.

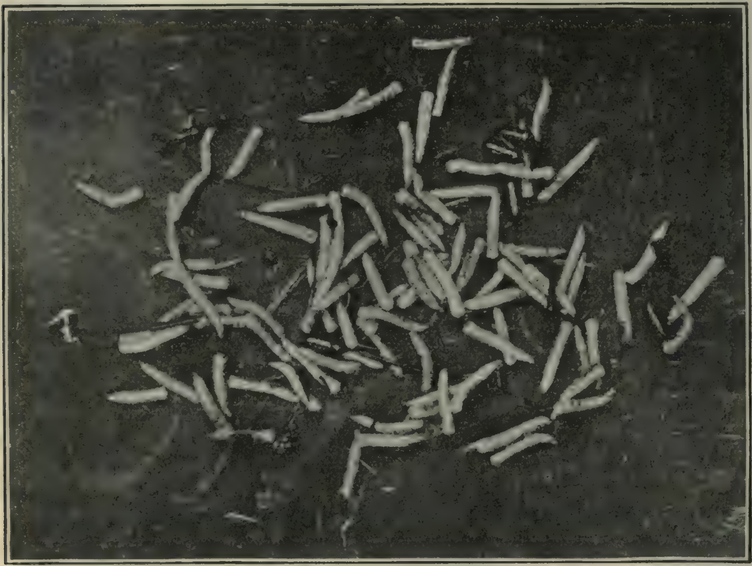

FIG. 6.—Larvæ, or maggots, of the house fly. About natural size. (Newstead.)

The pupæ (fig 7), or "sleepers," are more or less barrel shaped and dark brown in color. In midsummer this stage usually lasts from 3 to 6 days. The pupa stage is easily affected by temperature changes and may be prolonged during hibernation for as long as 4 or 5 months. Numerous rearing experiments in various parts of the country have shown that the shortest time between the deposition of eggs and the emergence of the adult fly is 8 days, and 10 and 12 day records were very common.

The adult fly, upon emerging from the puparium, works its way upward through the soil or manure and upon reaching the air it crawls about while its wings expand and the body hardens and assumes its normal coloration. In from 2½ to 20 days, as previously stated, the female is ready to deposit eggs. As in the case of other periods of its life history, so the preoviposition period is prolonged considerably by the lower temperatures of spring and fall. In midsummer, with a developmental period of from 8 to 10 days from egg to adult, and a preoviposition period of from 3 to 4 days, a new generation would be started every 11 to 14 days. Thus the climate of the District of Columbia allows abundance of time for the development of from 10 to 12 generations every season.

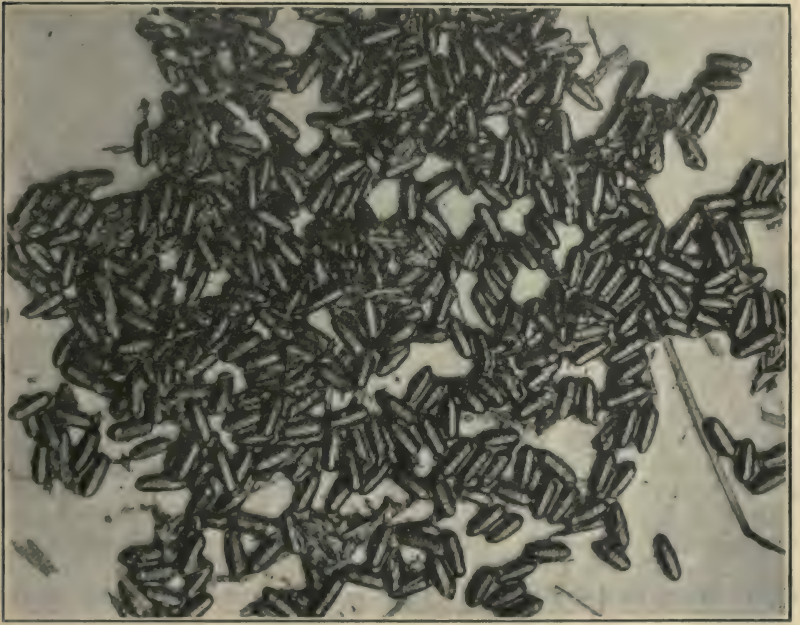

FIG. 7.—Pupæ of the house fly. About natural size. (Newstead.)

Flies usually remain near their breeding places if they have plenty of food, but experiments recently made at Dallas, Tex., show that they may migrate considerable distances; in fact, house flies, so marked that the particular individuals could be identified, have been recaptured in traps as far as 13 miles from the place where they were liberated.

HOW THE HOUSE FLY PASSES THE WINTER.

The prevailing opinion that the house fly lives through the winter as an adult, hiding in cracks and crevices of buildings, etc., appears to be erroneous. Under outdoor conditions house flies are killed during the first really cold nights, that is, when the temperature falls to about 15° or 10° F. In rooms and similar places protected from winds and partially heated during the winter flies have been kept alive in cages for long periods; but they never lived through the entire winter. In longevity experiments one record of 70 days and another of 91 days was obtained. No uncaged house flies were found during three seasons' observations in unheated and only partially heated attics, stables, unused rooms, etc., where favorable temperature conditions prevailed. The common occurrence in such places of the cluster fly and a few other species, which may be easily mistaken for the house fly, is responsible for the prevailing belief as to the way the house fly overwinters. There is therefore no reliable evidence whatever that adult house flies emerging during October and November pass the winter and are able to deposit their eggs the following spring, although they may continue active in heated buildings until nearly the end of January. On the other hand, there is evidence that house flies pass the winter as larvæ and pupæ, and that they sometimes breed continuously throughout the winter. In experiments at both Dallas, Tex., and Bethesda, Md., house flies have been found emerging during April from heavily infested manure heaps which had been set out and covered with cages during the preceding autumn. In the Southern States, during warm periods in midwinter, house flies may emerge and become somewhat troublesome; they frequently lay eggs on warm days.

The second way in which the house fly may pass the winter is by continuous breeding. House flies congregate in heated rooms with the approach of the winter season. If no food or breeding materials are present they eventually die. However, where they have access to both food and suitable substances for egg laying they will continue breeding just as they do outdoors during the summer. Even in very cold climates there are undoubtedly many places, especially in cities, where house flies would have opportunity to pass the winter in this manner.

CARRIAGE OF DISEASE BY THE HOUSE FLY.

The body of the house fly is covered thickly with hairs and bristles of varying lengths, and this is especially true of the legs. Thus, when it crawls over infected material it readily becomes loaded with germs, and subsequent visits to human foods result in their contamination. Even more dangerous than the transference of germs on the legs and body of the fly is the fact that bacteria are found in greater numbers and live longer in its alimentary canal. These germs are voided, not only in the excrement of the fly, but also in small droplets of regurgitated matter which have been called " vomit spots." When we realize that flies frequent and feed upon the most filthy substances (it may be the excreta of typhoid or dysentery patients or the discharges of one suffering from tuberculosis), and that subsequently they may contaminate human foods with their feet or excreta or vomit spots, the necessity and importance of house-fly control is clear.

In army camps, in mining camps, and in great public works, where large numbers of men are brought together for a longer or shorter time, there is seldom the proper care of excreta, and the carriage of typhoid germs from the latrines and privies to food by flies is common and often results in epidemics of typhoid fever.

And such carriage of typhoid is by no means confined to great temporary camps. In farmhouses in small communities, and even in badly cared for portions of large cities, typhoid germs are carried from excrement to food by flies, and the proper supervision and treatment of the breeding places of the house fly become most important elements in the prevention of typhoid.

In the same way other intestinal germ diseases, such as Asiatic cholera, dysentery, enteritis (inflammation of the intestine), and infantile diarrhea, are all so carried. There is strong circumstantial evidence also that tuberculosis, anthrax, yaws, ophthalmia, smallpox, tropical sore, and the eggs of parasitic worms may be and are carried in this way. In the case of over 30 different disease-organisms and parasitic worms, actual laboratory proof exists, and where lacking is replaced by circumstantial evidence amounting almost to certainty.

EXCLUDING AND CAPTURING FLIES.

The principal effort to control this dangerous insect must be made at the source of supply—its breeding places. Absolute cleanliness and the removal or destruction of anything in which flies may breed are essential; and this is something that can be done even in cities. Perhaps it can be done more easily in the cities than in villages, on account of their greater police power and the lesser insistence on the rights of the individual. Once people are educated to the danger and learn to find the breeding places, the rest will be easy.

In spite of what has just been said, it is often necessary to catch or otherwise destroy adult flies, or to protect food materials from contamination and persons from annoyance or danger; hence the value of fly papers and poisons, flytraps, and screens.

THE USE OF SCREENS.

A careful screening of windows and doors during the summer months, with the supplementary use of sticky fly papers, is a protective measure against house flies known to everyone. As regards screening, it is only necessary here to emphasize the importance of keeping food supplies screened or otherwise covered so that flies can gain no access to them. This applies not only to homes, but also to stores, restaurants, milk shops, and the like. Screening, of course, will have no effect in decreasing the number of flies, but at least it has the virtue of lessening the danger of contamination of food. Screens should be well made and durable. In dry climates black or painted screen wire will last fairly well and give satisfaction; in moderately moist climates, however, it will rust, and it is better to use the best grades of galvanized wire; and in humid regions, especially if near the seacoast, bronze wire or monel metal wire is undoubtedly the least expensive in the long run. A screen having a mesh of 14 strands to the inch, the kind commonly sold, is satisfactory for excluding flies, if unbroken, but a finer mesh is necessary to exclude the smaller mosquitoes.

FLY PAPERS AND POISONS.

The use of sticky fly papers to destroy flies that have gained access to houses is well known. Fly-poison preparations also are common. Many of the commercial fly poisons contain arsenic, and their use in the household is attended with considerable danger, especially to children. This danger is less with the use of a weak solution of formalin. A very effective fly poison is made by adding 3 teaspoonfuls of the commercial formalin to a pint of milk or water sweetened with a little brown sugar. A convenient way of exposing this poison is by partly filling an ordinary drinking glass with the solution. A saucer or plate is then lined with white blotting paper cut the size of the dish and placed bottom up over the glass. The whole is then quickly inverted and a small match stick placed under the edge of the glass. As the solution evaporates from the paper more flows out from the glass and thus the supply is automatically renewed.

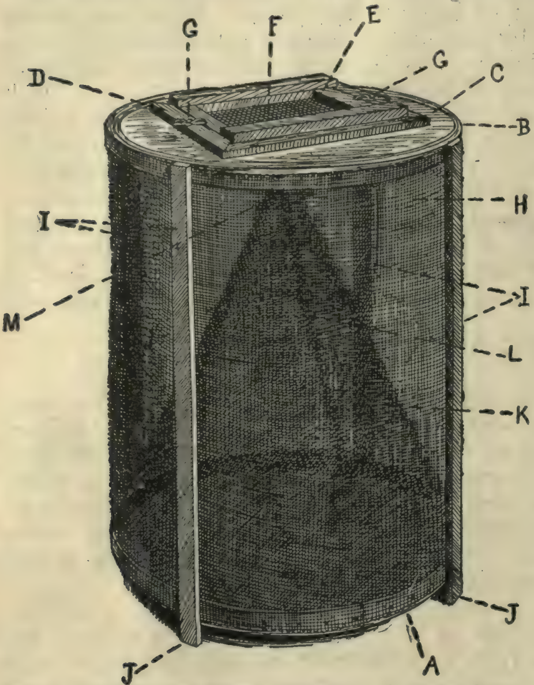

FIG. 8.—Conical hoop flytrap, side view. *A*, Hoops forming frame at bottom. *B*, Hoops forming frame at top. *C*, Top of trap made of barrel head. *D*, Strips around door. *E*, Door frame. *F*, Screen on door. *G*, Buttons holding door. *H*, Screen on outside of trap. *I*, Strips on side of trap between hoops. *J*, Tips of these strips projecting to form legs. *K*, Cone. *L*, United edges of screen forming cone. *M*, Aperture at apex of cone. (Bishopp.)

FLYTRAPS.

Flytraps may be used to advantage in decreasing the number of flies. Their use has been advocated not only because of the immediate results, but because of the chances that the flies may be caught before they lay eggs, and the number of future generations will be reduced greatly.

Many types of flytraps are on the market. As a rule the larger ones are the more effective. Anyone with a few tools can construct flytraps for a small part of the price of the ready-made ones. A trap (fig. 8) which is very effective in catching flies and is easily made, durable, and cheap, may be made of four barrel hoops, four laths, a few strips of boxing, and 8½ lineal feet of screening, 24 inches wide. (For greater details see Farmers' Bulletin 734.)

The effectiveness of the traps will depend on the selection of baits. A good bait for catching house flies is 1 part of blackstrap molasses to 3 parts of water, after the mixture has been allowed to ferment for a day or two. Overripe or fermenting bananas crushed and placed in the bait pans give good results, especially with milk added to them. A mixture of equal parts brown sugar and curd of sour milk, thoroughly moistened, gives good results after it has been allowed to stand for three or four days.

PREVENTING THE BREEDING OF FLIES.

As previously stated, fly papers, poisons, and traps are at best only temporary expedients. The most logical method of abating the fly nuisance is the elimination or treatment of all breeding places. It would appear from what is known of the life history and habits of the common house fly that it is perfectly feasible for cities and towns to reduce the numbers of this annoying and dangerous insect so greatly as to render it of comparatively slight account. On farms also, in dairies, and under rural conditions generally, much can and should be done to control the fly, which here, as elsewhere, constitutes a very serious menace to health.

CONSTRUCTION AND CARE OF STABLES.

In formulating rules for the construction and care of stables and the disposal of manure the following points must be taken into consideration. In the first place, the ground of soil-floor stables may offer a suitable place for the development of fly larvæ: The larvæ will migrate from the manure to the soil and continue their growth in the moist ground. This takes place to some extent even when the manure is removed from the stables every day. Even wooden floors are not entirely satisfactory unless they are perfectly water-tight, since larvæ will crawl through the cracks and continue their development in the moist ground below. Water-tight floors of concrete or masonry, therefore, are desirable. Flies have been found to breed in surprising numbers in small accumulations of material in the corners of feed troughs and mangers, and it is important that such places be kept clean.

FLY-TIGHT MANURE PITS.

The Bureau of Entomology for a number of years has advised that manure from horse stables be kept in fly-tight pits or bins. Such pits can be built in or attached to the stable so that manure can be easily thrown in at the time of cleaning and so constructed that the manure can be readily removed. It is desirable that the manure be placed in these fly-proof receptacles as soon as possible after it is voided. The essential point is that flies be prevented from reaching the manure, and for this reason the pit or bin must be tightly constructed, preferably of concrete, and the lid kept closed except when the manure is being thrown in or removed. The difficulty has been that manure often becomes infested before it is put into the container, and flies frequently breed out before it is emptied and often escape through the cracks. To obviate these difficulties a manure box or pit with a modified tent trap or cone trap attached is desirable.

In order to retain the fertilizing value of manure to the greatest extent it is advisable that air be excluded from it as much as possible and that it be protected from the leaching action of rains. This being the case, there is really no necessity for covering a large portion of the top of the box with a trap, but merely to have holes large enough to attract flies to the light, and to cover these holes with ordinary conical traps, with the legs cut off, so that the bottoms of the traps will fit closely to the box. The same arrangement can be made where manure is kept in a pit. If manure boxes or pits are kept fly tight they are satisfactory under farm or dairy conditions for the storage of manure during the busy season when it can not be hauled out daily.

FREQUENCY WITH WHICH MANURE SHOULD BE REMOVED IN CITIES AND TOWNS.

In deciding the question as to how often manure should be removed in cities and towns, it should be borne in mind that when the larvæ have finished feeding they will often leave the manure and pupate in the ground below or crawl some distance away to pupate in débris under boards or stones and the like. Hence the manure should be removed before the larvæ reach the migratory stage; that is to say, removal is necessary every three days, and certainly not less frequently than twice a week during the summer months. A series of orders issued in 1906 by the health department of the District of Columbia, on the authority of the Commissioners of the District, covers most of these points, and these orders, which may well serve as a model to other communities desiring to undertake similar measures, may be briefly condensed as follows:

HEALTH OFFICE REGULATIONS FOR CONTROL OF HOUSE FLIES IN CITIES.

All stalls in which animals are kept shall have the surface of the ground covered with a water-tight floor. Every person occupying a building where domestic animals are kept shall maintain in connection therewith a bin or pit for the reception of manure and, pending the removal from the premises of the manure from the animal or animals, shall place such manure in said bin or pit. This bin shall be so constructed as to exclude rain water and shall in all other respects be water-tight, except as it may be connected with the public sewer. It shall be provided with a suitable cover and constructed so as to prevent the ingress and egress of flies. No person owning a stable shall keep any manure or permit any manure to be kept in or upon any portion of the premises other than the bin or pit described, nor shall he allow any such bin or pit to be overfilled or needlessly uncovered. Horse manure may be kept tightly rammed into well-covered barrels for the purpose of removal in such barrels. Every person keeping manure in the more densely populated parts of the District shall cause all such manure to be removed from the premises at least twice every week between June 1 and October 31, and at least once every week between November 1 and May 31 of the following year. No person shall remove or transport any manure over any public highway in any of the more densely populated parts of the District except in a tight vehicle, which, if not inclosed, must be effectually covered with canvas, so as to prevent the manure from being dropped. No person shall deposit manure removed from the bins or pits within any of the more densely populated parts of the District without a permit from the health officer. Any person violating any of the provisions shall, upon conviction thereof, be punished by a fine of not more than $40 for each offense.

Not only must horse stables be cared for, but chicken yards, piggeries, and garbage receptacles as well. In cities, with better methods of disposal of garbage and with the lessening of the number of horses and horse stables consequent upon electric street railways, bicycles, and automobiles, the time may come, and before very long, when window screens may be discarded.

DISPOSAL OF MANURE IN RURAL AND SUBURBAN DISTRICTS.

The control of flies in rural and suburban districts offers a much more difficult problem. Here it is often out of the question to remove all manure from the premises twice a week, and the problem is to find some method of disposal or storage which will conserve the fertilizing value of the manure and at the same time prevent all flies from breeding, or destroy such as do breed there.

With this idea in mind, it has been recommended that stable manure be collected every morning and hauled out at once and spread rather thinly on the fields. This procedure is advisable from the point of view of getting the maximum fertilizing value from the manure. Immediate spreading on the fields is said largely to prevent the loss of plant food which occurs when manure is allowed to stand in heaps for a long time. This method will be effective in preventing the breeding of flies only if the manure is hauled out promptly every morning and spread thinly so that it will dry, since it is unfavorable for fly development in desiccated condition. The proper scattering of the manure on the fields is best and most easily and quickly accomplished by the use of a manure spreader, and many dairies, and even farms, are practicing the daily distribution of manure in this way. Removal every three or four days will not be sufficient. Observations have shown that if manure becomes flyblown and the maggots attain a fairly good size before the manure is scattered on the fields, they can continue their development and will pupate in the ground.

CHEMICAL TREATMENT OF MANURE TO DESTROY FLY MAGGOTS.

During the summer months, when fly breeding is going on most actively, the farmer is also busy and often can not spare the time to remove manure regularly. The general practice, therefore, has been to keep the manure in heaps located, as a rule, very near the stables. How can fly breeding be prevented in such accumulations? As a result of recent investigations, it is now possible to point out two methods which are practical and effective.

The first is the treatment of the manure pile with chemical substances which will kill the eggs and maggots of the house fly. The Bureau of Entomology, in cooperation with the Bureau of Chemistry and the Bureau of Plant Industry, has conducted a series of experiments in which a large number of chemicals were applied to infested manure and observations made not only on their efficiency in killing the maggots but also as to their effect on the chemical composition and bacterial flora of the manure. The object was to find some cheap chemical which would be effective in destroying the fly larvæ and at the same time would not reduce the fertilizing value of the manure.

TREATMENT WITH HELLEBORE.

Of the numerous substances tried, the one which seems best to fulfill these conditions is powdered hellebore.[9] For the treatment of manure a water extract of the hellebore is prepared by adding ½ pound of the powder to every 10 gallons of water, and after stirring it is allowed to stand 24 hours. The mixture thus prepared is sprinkled over the manure at the rate of 10 gallons to every 8 bushels (10 cubic feet) of manure. From the result of 12 experiments with manure piles treated under natural conditions it appears that such treatment results in the destruction of from 88 to 99 per cent of the fly larvæ.

Studies of treated manure indicated that its composition and rotting were not interfered with. Furthermore, several field tests showed that there was no apparent injury to growing crops when fertilized with treated manure.

Since the solution is somewhat poisonous it should not be left exposed where it might be drunk by livestock. It is quite safe to say that chickens will not be injured by pecking at hellebore-treated manure. This has been tested carefully. Hellebore can be obtained both in ground and powdered form, but the powder gives the best results in the destruction of fly larvæ.

TREATMENT WITH POWDERED BORAX.

Another chemical found to be even more effective as a larvicide is powdered borax. This substance is available in commercial form in all parts of the country. It has the advantage of being comparatively nonpoisonous and noninflammable and is easily transported and handled. The minimum amount necessary to kill fly larvæ was found to be 0.62 pound per 8 bushels of manure, or about 1 pound per 16 cubic feet. Best results were obtained when the borax was applied in solution, or when water was sprinkled on after the borax had been scattered evenly over the pile. Borax is not only effective in killing the larvæ, but when it comes in contact with the eggs it prevents them from hatching. When applied at the rate of 1 pound to 16 cubic feet it was found to kill about 90 per cent of the larvæ, heavier applications killing from 98 to 99 per cent.

Borax has no injurious effect on the chemical composition or rotting of the manure. However, when added in large quantities with manure to the soil it will cause considerable injury to growing plants. A number of experiments have been conducted to determine the effect on crops of the use of manure treated with borax as herein recommended. When applied at the rate of 15 tons per acre it appears that no injury as a rule will follow. Some crops are more sensitive to borax than others, and also the tendency to injury appears to vary on different soils. It is necessary, therefore, to repeat the warning issued in connection with a previous bulletin[10] on this subject, that great care be exercised, in the application of borax, that the manure does not receive more than 1 pound for every 16 cubic feet, and that not more than 15 tons of manure so treated are applied to the acre.

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[9] *Veratrum viride* or *V. aloum.*

In view of the possible injury from the borax treatment as a result of carelessness in applying it, or from other unforeseen conditions, it is recommended that horse manure and other farmyard manures which are to be used as fertilizer be treated with hellebore. Borax, on the other hand, is such a good larvicide that it can be used with advantage on the ground of soil-floor stables, in privies, on refuse piles, and on any accumulations of fermenting organic matter which are not to be used for fertilizing purposes.

TREATMENT WITH CALCIUM CYANAMID AND ACID PHOSPHATE.

Many experiments with mixtures of commercial fertilizers were tried to determine whether fly larvæ would be killed by any substance the addition of which would increase the fertilizing value of the manure. A mixture of calcium cyanamid and acid phosphate was found to possess considerable larvicidal action. Several experiments showed that ½ pound of calcium cyanamid plus ½ pound of acid phosphate to each bushel of manure gave an apparent larvicidal action of 98 per cent. The mixture in the form of a powder was scattered evenly over the surface and then wet down with water. The use of this mixture adds to the manure two important elements, nitrogen and phosphorus.

MAGGOT TRAP FOR DESTRUCTION OF FLY LARVÆ FROM HORSE MANURE.

The second method of handling manure is one which does not require the application of chemicals. It is based on the fact, mentioned on page 4, that the larvæ of the house fly, a few hours before they are ready to pupate, show a strong tendency to migrate. This migration takes place mostly at night, and the larvæ sometimes crawl considerable distances from the manure pile. Now it is possible by means of a very simple arrangement called a maggot trap to destroy fully 99 per cent of all maggots breeding in a given lot of manure. A successful maggot trap which the Maryland Agricultural College constructed at the college barn is shown in Figure 9. The trap was designed by R. H. Hutchison and constructed under his supervision. The manure, instead of being thrown on the ground, is heaped carefully on a slatted platform, which stands about 1 foot high. This particular platform measures 10 by 20 feet. There are six 2 by 4 pieces running lengthwise 2 feet apart. Across these are nailed 1-inch strips with ½ to 1 inch spaces between them. The wooden platform stands on a concrete floor, and a rim or wall of concrete 4 inches high surrounds the floor. The floor slopes a little toward one corner, from which a pipe leads to a small cistern near by. This pipe is plugged with a stopper of soft wood, and the concrete floor is filled with water to a depth of 1 inch in the shallowest part. Flies will lay their eggs on the manure as usual, but the maggots, when they have finished feeding and begin to migrate, crawl out of the manure, drop into the water below, and are drowned. Each week the plug is removed from the pipe, and all the maggots are washed into the cistern. The floor is then cleaned of any solid particles by means of a long-handled stable broom or by a strong stream of water from a hose. The pipe being again plugged, the floor is again partly filled with water and the trap is ready for another week's catch. A platform of this size will hold the manure accumulating from four horses during the period of four months, or about 20 days' accumulation from 25 horses, if the heap is well built and made at least 5 feet high.

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[10] Department Bulletin 118, U. S. Department of Agriculture, p. 25.

Experience with this maggot trap clearly indicates that best results can be secured if the manure is compactly heaped on the platform and kept thoroughly moistened. It is best to apply a small amount of water each morning after the stable cleanings have been added to the pile.

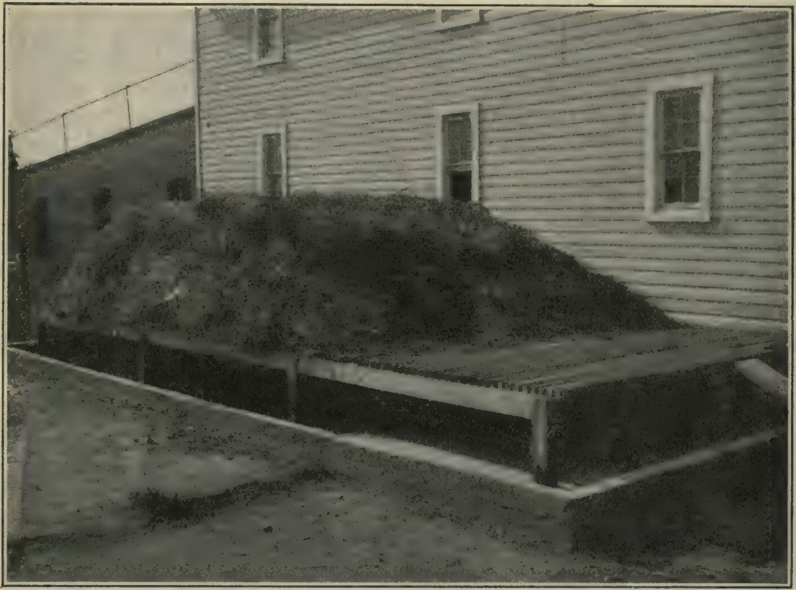

FIG. 9.—A maggot trap for house-fly control. View showing the concrete basin containing water in which larvæ are drowned, and the wooden platform on which manure is heaped. (Hutchison.)

It should be borne in mind that in order to make this trap a success the platform beneath the pile must be kept comparatively free of accumulations of manure, and moisture applied regularly to drive the maggots out.

COMPACT HEAPING OF MANURE.

Another method of disposing of manure has been recommended by English writers. The manure is built up in a compact rectangular heap, the sides of which are beaten hard with shovels. The ground around the edges of the heap is made smooth and hard and loose straw is placed in small windrows around the manure pile about 1 foot from the edge. The exclusion of the air, together with the high temperature and gases formed by fermentation, tends to make the heap unfavorable for the development of fly larvæ. Those which do happen to develop in the surface layers will migrate and pupate in the ring of straw around the heap, where they are destroyed by burning.

GARBAGE DISPOSAL AND TREATMENT OF MISCELLANEOUS BREEDING PLACES.

It is just as true under farm conditions as in cities that breeding places other than horse manure must be attended to. Garbage must be disposed of, hog and poultry manure must be cared for, and especially on dairy farms it is extremely important that every precaution be taken to prevent the contamination of milk by flies.

It is very desirable that all refuse possible, accumulated from cities and towns, be burned. Incineration has been practiced successfully by a number of towns and cities with populations of from 10,000 to 15,000 and over. In larger cities provision should be made for burning carcasses as well as garbage and other refuse. If city and town garbage is sold to hog feeders the municipal authorities should have control of the sanitary conditions about the feeding yards, as there is great danger from fly breeding in such places if not kept clean.

SEWAGE DISPOSAL IN RELATION TO THE PREVENTION OF FLY-BORNE DISEASES.

In the consideration of these measures we have not touched upon the remedies for house flies breeding in human excrement. On account of the danger of the carriage of typhoid fever, the dropping of human excrement in the open in cities or towns, either in vacant lots or in dark alleyways, should be made a misdemeanor, and the same care should be taken by the sanitary authorities to remove or cover up such depositions as is taken in the removal of the bodies of dead animals. For modern methods of sewage disposal adapted for farm use one should consult Department of Agriculture Department Bulletin No. 57. In the absence of modern methods of sewage disposal, absolutely sanitary privies are prime necessities, whether in towns or on farms. Directions for building and caring for such privies will be found in Farmers' Bulletin 463 and in Yearbook Separate 712, "Sewage Disposal on the Farm." The box privy is always a nuisance from many points of view, and is undoubtedly dangerous as a breeder of flies which may carry the germs of intestinal diseases. The dry-earth treatment of privies is unsatisfactory. No box privy should be permitted to exist unless it is thoroughly and regularly treated with some effective larvicide. Since the fecal matter in such privies is seldom used for fertilizing purposes it may well be treated liberally with borax. The powdered borax may be scattered two or three times a week over the exposed surface so as to whiten it.

WHAT COMMUNITIES CAN DO TO ELIMINATE THE HOUSE FLY.

Antifly crusades have been very numerous in recent years, and some have been noteworthy both in methods and in results. However, it will not be amiss here to emphasize the importance of concerted, organized effort on the part of whole communities, not only cities, but suburban and rural neighborhoods as well. By the most painstaking care one may prevent all fly breeding on his premises, but it will avail him little if his neighbors are not equally careful. Some sort of cooperation is necessary. One of the first and most important elements in any antifly crusade is a vigorous and continued educational campaign. It has been the experience of those who have undertaken such crusades that people generally regard the fly as a somewhat harmless nuisance and that the first work of the campaign was to bring the people to a realization of the dangers from flies and the possibility of getting rid of them. In the educational campaign every possible means of publicity can be employed, including newspapers, lectures, moving pictures, posters, handbills, cartoons, instruction in schools, etc.

The antifly crusade is a matter of public interest and should be supported by the community as a whole and engineered by the health officers. But health officers can do little toward the necessary work of inspection and elimination without funds, and therefore the support of the campaign must manifest itself in increased appropriations for public-health work. Very often it is lack of funds which prevents the health officers from taking the initiative in the antifly crusades, and there must necessarily be much agitation and education before they can profitably take up the work. Right here lies a field for civic associations, women's clubs, boards of trade, etc., to exercise their best energy, initiative, and leadership.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

November 12, 1923.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1409

TURKEY RAISING

THE BUSINESS OF TURKEY RAISING, where conditions are suitable, is quite profitable. It is usually carried on as a side line on general farms, though in some parts of the United States it constitutes the chief source of revenue from farming operations.

As compared with 20 years ago the number of turkeys now raised annually in the United States is much less. This decline seems to have been more marked with respect to turkey raising on the general farm rather than as a commercial enterprise. Several reasons may be attributed for the decline in numbers, but it is generally admitted that practically all the obstacles to success can be overcome.

One of the outstanding reasons why turkey raising has not been developed more extensively in recent years has been a failure to appreciate the value of the industry in supplying the Nation with one of its most popular articles of diet. There has been a general lack of interest in turkey raising as an enterprise; there has been a dearth of knowledge as to the best methods in the management of the breeding stock, particularly the growing stock; there has been little investigational work in the control of disease and other matters of primary importance in producing turkey meat at a profit.

This bulletin has been prepared primarily to bring to the attention of those interested in turkey raising some information which may be of value in improving conditions and thus give rise to more satisfactory results.

This bulletin is a revision of and supersedes Farmers' Bulletin 791.

Washington, D. C. April, 1924

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TURKEY RAISING.

By MORLEY A. JULL, *Senior Poultryman*, and ALFRED R. LEE, *Poultryman, Animal Husbandry Division*, **Bureau** *of Animal Industry.*

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THE TURKEY INDUSTRY OF THE UNITED STATES.

TURKEY RAISING in the United States has long been an important enterprise because of the great quantities of turkey meat required annually. Since there is always likely to be a keen demand for such a popular article of diet, it is desirable to encourage the raising of turkeys in adequate numbers. Steps must also be taken to make turkey raising more profitable, for the recent decline in the number raised annually is due to certain outstanding difficulties, the nature of which is discussed later.

Turkey raising is a very adaptable enterprise, since these fowls are being raised in practically all parts of the United States. The more important sections of production are the Middle Western and Southwestern States. In these States an enormous number of small flocks is raised annually on the grain farms and there are also many large commercial flocks. The census of 1920, the latest figures available, shows the six leading States in production of turkeys to be Texas, Missouri, Oklahoma, California, Kentucky, and Virginia. Formerly large numbers were raised in New England, but in recent years there has been a decided decrease. There have been decreases in other parts of the country as well, and this has resulted in a marked decrease in the number raised in the country as a whole. According to the census of 1900, there were on farms in the United States 6,594,695 turkeys; in 1910 there were 3,688,708; and in 1920 there were 3,627,028. Although the census enumerations were taken at different times of the year, the totals are fairly representative of the trend in numbers.

Several causes have been assigned for the decrease in the number raised. The rearing of the young stock, in some respects at least, requires more detailed attention than is the case with most other classes of poultry. The prevalence of blackhead has been a dominant factor. The birds range widely and frequently trespass upon the property of neighbors, the vexation tending to discourage turkey raising. Finally, little attention has been given the more important problems of the industry by investigators and others interested.

On the other hand, there is good opportunity for further development. Turkey raising is profitable, particularly where conditions are suitable and proper methods of management are followed. Turkeys can be raised successfully under very simple conditions, so that the capital outlay in the enterprise is quite small. Except during the growing season, the management of the flock is a fairly simple matter. Of course, considerable care must be exercised in maintaining constitutional vigor in the breeding stock; the flock must be kept relatively free from disease; and the soil, especially where the poults are fed, must be kept sanitary. But these factors can be dealt with when proper care is exercised. Moreover, turkeys are inclined to range freely, and in doing so they destroy many injurious insects and pick up much waste grain. This reduces the costs of raising and increases the profits. Prices for live and dressed turkeys have always been considerably higher than those for other classes of poultry.

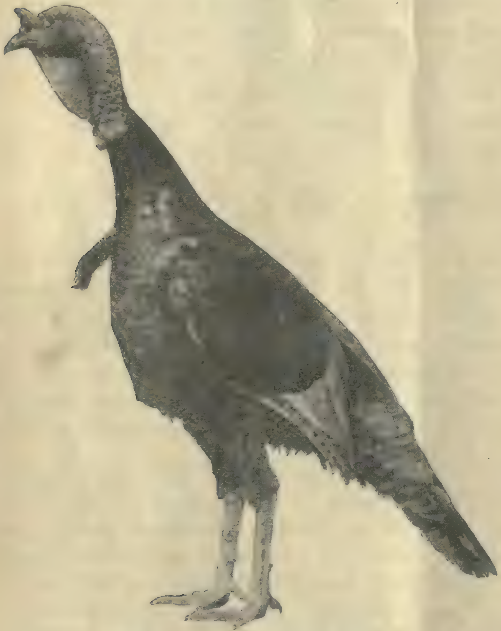

FIG. 1.—Bronze turkey, male.

VARIETIES.

All domestic varieties have descended from wild stocks, comprising four varieties: the eastern wild turkey, which ranged over the eastern part of the United States from Maine to Florida; the Florida wild turkey, which ranged over southern Florida; the Rio Grande wild turkey, which ranged over southern Texas and northwestern Mexico; and the Mexican wild turkey, which ranged over Arizona, western New Mexico, southern Colorado, and Mexico. It is probable, however, that these four wild varieties were of common origin and that most of our domesticated varieties, especially the Bronze, have descended from the Mexican wild variety.

There are six varieties of domestic turkeys. These are recognized as standard varieties by the American Poultry Association, an association which has as its primary function the promotion of standard qualities in all breeds and varieties of poultry in America. The association publishes the "Standard of Perfection," which contains a concise description of breeds and varieties of poultry and numerous illustrations of the more important. Following is a brief description of each of the six varieties, which include the Bronze, White Holland, Bourbon Red, Black, Narragansett, and Slate.

THE BRONZE.

In color the Bronze male (fig. 1) is distinguished by the rich, brilliant copperish sheen of plumage in neck, wing bows and wing coverts, breast, back, body, and fluff, against a background of black and brown. The white barring of the wings and the wide, pure-white edging of the main tail feathers and tail coverts make a strong contrast to the body color. The body color blends into an equally dark fluff with a wide, brilliant bronze band extending across it and tipped with a narrow edging of white. The lighter, more brilliant bronze barring of the feathers of the neck, breast, wing bows, and wing coverts terminates in a narrow black band or bar extending across the end of each feather. The plumage of the female (fig. 2) is similar to that of the male, except for an edging of white on the black bars in these sections and in the feathers of the back. This white edging is narrow in the front of the body and gradually widens as it approaches the rear. Both sexes have the same color pattern in the main tail feathers and coverts, with brown barring on a dull black background. Each main tail feather and covert has a wide black and bronze band near its end and terminates in a wide, white edging. Creaminess, yellow, or yellowish brown in the pure white edging of the main tail feathers and coverts of the Bronze indicates an admixture of wild-turkey blood.

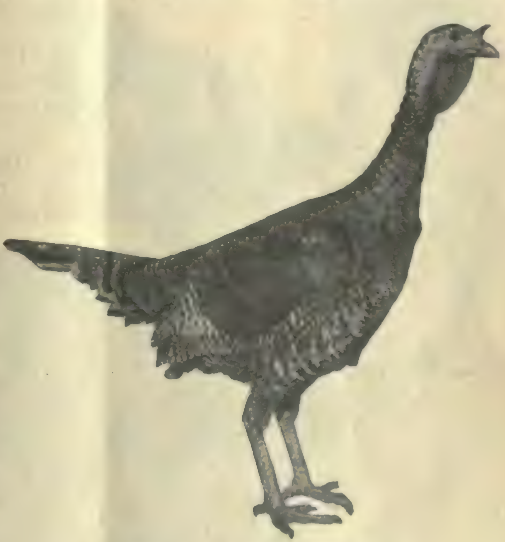
FIG. 2.—Bronze turkey hen.

THE WHITE HOLLAND.

The White Holland (fig. 3) probably originated as a "sport" from the Bronze or the wild turkey. Its plumage should be pure white in color and free from black flecking or ticking in all sections. The shanks and toes in this variety vary from white to pinkish white.

THE BOURBON RED.

The Bourbon Red (fig. 4) is a rich, deep brownish red in all sections except the primaries and secondaries of the wings and the main tail feathers, which should be pure white. More than one-fourth red in the wings or tail constitutes a standard disqualification in this variety. The rich reddish color is rather difficult to obtain without some black, and this black ticking or flecking is a rather common fault. A faded red approaching buff is also undesirable. The color of the female is similar to that of the male, but as in the other parti-colored breeds, the female is slightly lighter in color and has a narrow edging of white on breast, body, and thighs.

THE BLACK.

The Black turkey (fig. 5), known in England as the Norfolk turkey, has solid black color with a lustrous greenish-black surface in all sections. Objectionable white tipping in the feathers of young turkeys of this variety often disappear after the first molt. Any variation from the solid black color, whether in brown or bronze shading, should be carefully avoided in breeding this variety.

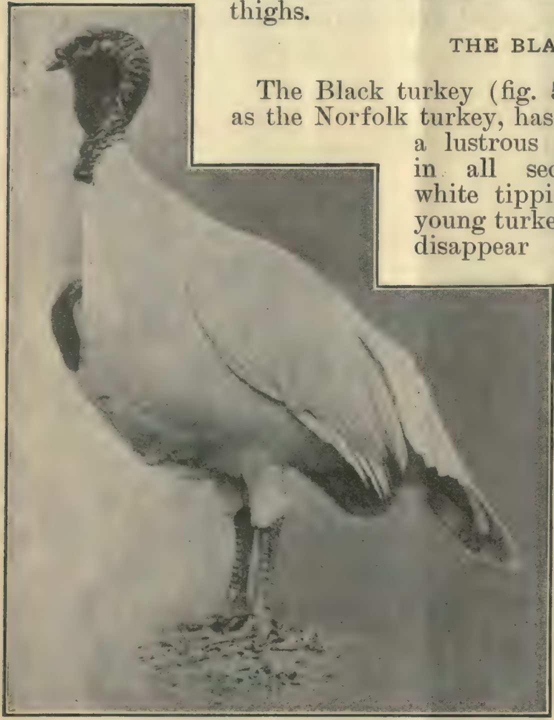

FIG. 3.—White Holland turkey, male.

THE NARRAGANSETT.

The Narragansett turkey (fig. 6) has a general resemblance in color pattern to the Bronze, but in contrast to the bronze barring narrowly edged with black, the Narragansett has metallic black and light steel-gray edging and barring. It has a dark background of metallic black and a broad white edging, showing more black in its edging as the body is approached. The general effect is much lighter in the Narragansett, however, on account of the whiteness or steel-gray color in the black body plumage, the white wing band, and white edging of main tail feathers and coverts. In all these sections the light steel-gray or white edging terminates in a black band.

The female plumage is similar to that of the male in this variety, although it shows more whiteness or light steel-gray color in the back, and the ends of the feathers in other sections terminate in an edging of light gray, approaching white. In the female, as in the male, the primaries and secondaries are evenly and distinctly barred with black and white or light gray. The female in general presents a lighter appearance than the male. There should be a rich metallic black but no bronze barring in the females. The offspring of a Narragansett mating, however, sometimes show bronze color, but such birds should not be bred.

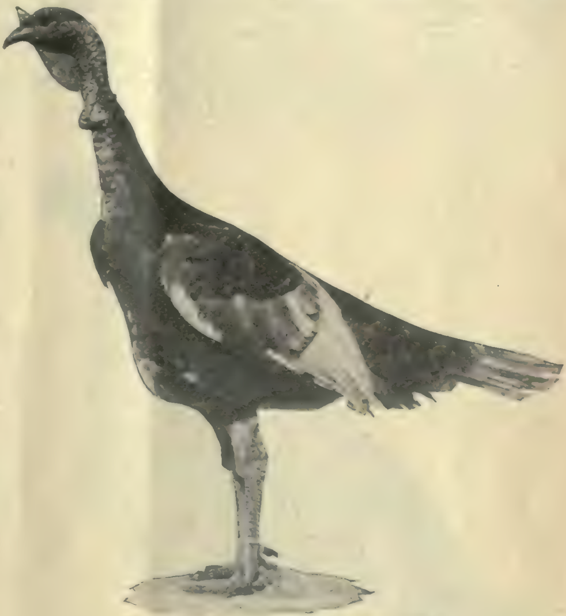

FIG. 4.—Bourbon Red turkey, male.

THE SLATE.

The Slate turkey (fig. 7) has an ashy-blue or slaty-colored plumage, sometimes dotted with tiny black spots. The less of this black the better, and any other foreign color, such as white, buff, or red, is undesirable. This variety does not breed very true to color and many of the offspring show both solid white and black as well as black and white ticking and splashing. This variety has dark lead or slaty-blue shanks and toes.

STANDARD WEIGHTS OF TURKEYS.

Until the sex can be distinguished the young of domestic turkeys are called "poults"; thereafter, up to 1 year of age, young birds are called cockerels and pullets. Birds over 1 year old are called cocks and hens.

The standard weights of the different varieties of turkeys as given in the Standard of Perfection are as follows:

Standard weights of turkeys at various ages.

Variety.	Adult cock (2 years old or over).	Yearling cock (1 year old and less than 2).	Cockerel (less than 1 year old).	Hen (1 year old or over).	Pullet (less than 1 year old).
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Bronze	36	33	25	20	16
Bourbon Red	30	25	20	18	14
Narragansett	30	25	20	18	14
White Holland	28	24	20	18	14
Black	27	22	18	18	12
Slate	27	22	18	18	12

SELECTING BREEDING STOCK.

The Bronze turkey is the heaviest and is probably more popular throughout the country than the other varieties. Since turkeys are sold by weight, the heaviest birds bring the largest returns. Regarding other characteristics, it is quite generally asserted that the Bronze is the hardiest variety, that the Bourbon Red and White Holland are the most domestic, and that the White Holland is the most prolific. These qualities are possessed in different degrees by individuals of every variety, however, and can be developed by proper management and careful selection of breeding stock.

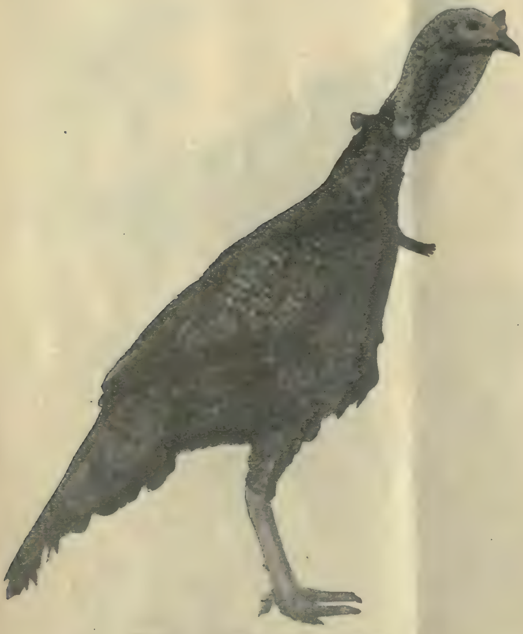

FIG. 5.—Black turkey, male.

The most satisfactory time of the year to select breeding stock is in November or December, especially before large numbers are sold for the Thanksgiving and Christmas markets. Selecting birds early in the season gives one a choice from a larger number, and, more important still, the best-developed birds can be saved for breeding instead of being marketed. New blood may be introduced into the flock or a start may be made with turkeys by purchasing hatching eggs instead of purchasing breeding stock. The purchasing of breeding stock, however, is recommended.

Turkeys are raised for meat rather than for egg production. The breeders should possess bodies well adapted for meat production. This means that they should have good, large frames. The back should be broad, especially at the shoulders, and the breadth should be carried well back toward the tail. The body should be deep, with a full, well-rounded breast. Other points of importance include a full, bright eye, a broad head, stout legs set well apart and not too long. Above all else, be sure to select vigorous birds. This is of paramount importance and should never be overlooked.

Select or build up a flock of purebred turkeys, for they are more profitable than mongrels or crossbreds. Also, it is eminently desirable to maintain the flock up to standard qualities as far as possible. It costs no more to raise purebred stock than crossbreds or mongrels and the purebreds are usually heavier and command higher market prices. Then, again, where good standard qualities in respect to shape and color are maintained some of the birds can be sold for breeding purposes at increased prices.

MANAGEMENT OF BREEDING STOCK.

Results in turkey raising depend to a very large extent on the kind of breeding stock that is used each year, and the manner in which it is managed. The breeding stock is the foundation of the turkey industry and the greatest care must be exercised in selecting both male and female breeders. Failure in this respect has undoubtedly been one of the principal reasons why satisfactory results have not been obtained on many farms and commercial plants. One of the first steps in improving conditions, therefore, is more careful selection of the breeding stock.

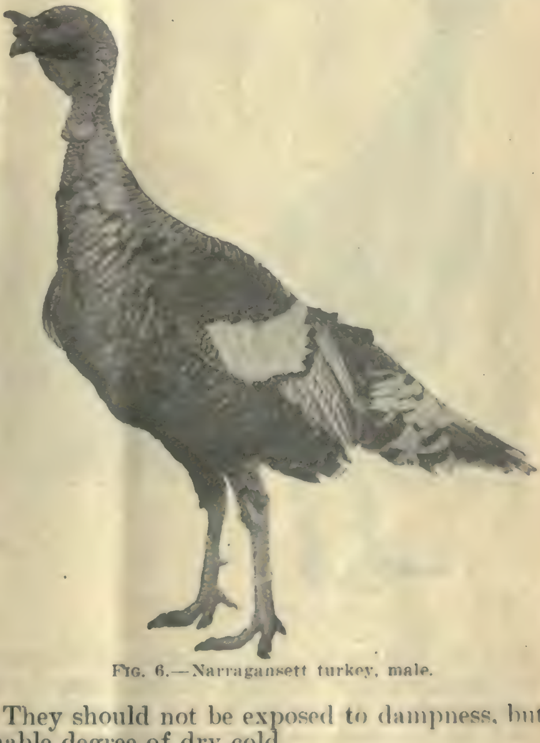

FIG. 6.—Narragansett turkey, male.

PROTECTION FROM WEATHER.

Under ordinary conditions turkeys do not require much protection from the weather. However, during cold winter weather such as prevails in the Northern States, it is well to provide covered roosting sheds. In most parts of the United States there is little need for a regular turkey house, but during damp and cold or stormy weather the turkeys should be given protection of some kind. They should not be exposed to dampness, but they can stand a reasonable degree of dry cold.

BREEDING PENS OR INCLOSURES.

It is the usual custom to allow the breeding flock free range throughout the breeding and laying season. (Fig. 8.) This seems to give the most satisfactory results, provided the nests are located so that the eggs can be gathered daily. On the other hand, if the breeding stock comprises quite a number of turkeys, it is advisable to use breeding pens or inclosures. (Fig. 9.) These, of course, should be of sufficient size to afford plenty of exercise, a flock of 15 birds requiring about 1 acre. The breeding pen need be only a very simple affair. Frequently the orchard serves this purpose very satisfactorily. A hog-proof fence about 4 feet high is enough to confine the turkeys; they are not inclined to fly over the fence, because they can not rest on the top wire. If board or rail fences are used, they will have to be of fairly good height with strands of wire run above the top to prevent the turkeys from perching on the fence. Where turkeys persist in flying over any kind of fence the flight feathers of one wing may be cut; or a small piece of light board may be fastened across the back by notching the board and tying it with a strip of cloth to each wing (fig. 10), so that when the wings are raised they strike against the board and prevent flying.

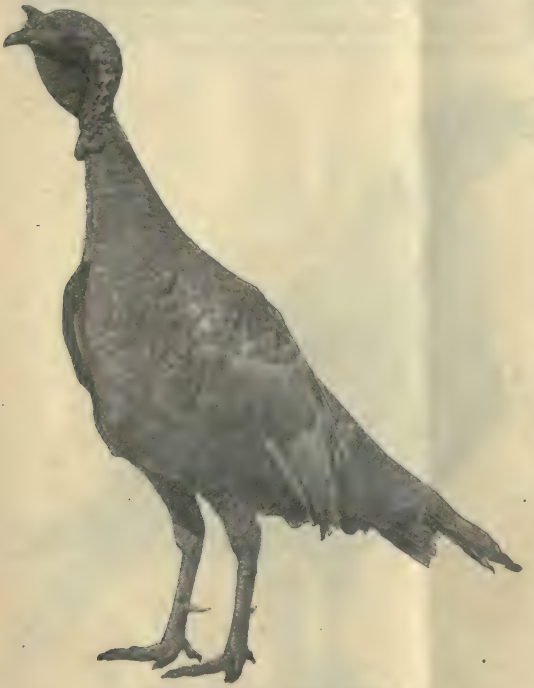
FIG. 7.—Slate turkey, male.

FEEDING THE BREEDING STOCK.

Feeding the breeding stock is a simple matter. It is important to keep the breeders in good condition, however, and they should be well fed but not overfed. Where turkeys have plenty of free range they should obtain an ample supply of insects, green feed, and seeds; but it is also advisable to give them a daily feed of grain, such as a ration of equal parts of oats, wheat, and corn. Considerable care should be taken to see that the grain fed is clean and wholesome, particularly the corn. During the cold winter months, especially in the northern part of the country, it may be necessary to feed grain twice a day. It is also well to provide the birds with vegetables, such as potatoes, turnips, mangels, or cabbage as a substitute for green feed. In addition, some kind of animal food is necessary for best results, and this can be supplied in the form of beef scraps, beef livers, or skim milk, either sweet or sour. Feed regularly and be careful not to overfeed, especially corn, and change the place of feeding frequently. The breeders should also have liberal supplies of grit, charcoal, and oyster shell.

MATING.

Best results from the standpoint of mating are obtained when about 15 females are mated to a healthy, vigorous "tom," or male bird. If more hens are kept more males should be used, but great care should be taken not to allow two toms to run together. When from 25 to 50 hens are kept the toms used should be alternated every other day. The proportion of hens to one tom used in mating gives a good idea of the relative importance of the male bird. His selection from the standpoint of type and constitutional vigor is a very important matter, although the females should also be kept up to standard as far as possible. The aim should be, in making up a breeding pen, to choose birds of standard weight. (See table on p. 5.)

Concerning the age of the birds to be used as breeders, most breeders prefer to mate a vigorous, well-grown tom (cockerel) with yearling hens or sometimes with early hatched pullets. If pullets are used they should be well matured, as there is great danger of lowering the vitality of the stock by using immature birds. Yearling and older toms can be used if desired, but sometimes there is danger of their excessive weight causing injury. At any rate, if a yearling or older tom is used, his spurs and nails should be trimmed. With respect to females, since egg production decreases materially after three years, it is advisable to replace 3-year-old females with young birds.

FIG. 8.—Breeding flock of Bronze turkeys on free range.

It is not advisable to inbreed turkeys. Inbreeding has been found in many cases to result in a great lowering of the vitality of the stock. It is well to secure new blood by purchasing male stock from an outside source. Great care should be exercised in selecting males from reliable breeders whose stock is first of all healthy and vigorous, approaches standard weight, and possesses other standard qualities to a high degree.

EGG PRODUCTION.

The time when turkeys naturally begin laying depends, of course, upon the section of the country in which they are being raised. Soon after mating begins the female looks for a nesting place, and about 10 days after the first mating she commences laying. Naturally, all the hens do not begin laying at the same time, and in a flock of about 15 the time of commencement may be spread over a period of six weeks. The number of eggs produced per bird depends upon the breeding of the stock as well as upon the management. Under ordinary circumstances, however, the average number of eggs per bird is about 20 in the first litter. Turkeys lay in litters; that is, they will lay about 20 eggs, and then go broody; and after getting over their brooding period they will lay a second or third lot, each subsequent litter containing fewer eggs. Some hens can be made to lay more than three litters. It is not well, however, to try to hatch the eggs of the late litters, as late-hatched turkeys are very rarely profitable.

Where broody chickens can be obtained to incubate the turkey eggs of the first litter, the turkey hen can be broken up from her broodiness and she will immediately begin to lay a second litter. This method of getting the turkey to lay her second litter shortly after the first one is very desirable, as it provides for the hatching of a relatively large number of early turkeys. The early hatched birds are the ones that grow and mature most satisfactorily, and therefore attain the best size for the Thanksgiving and Christmas markets.

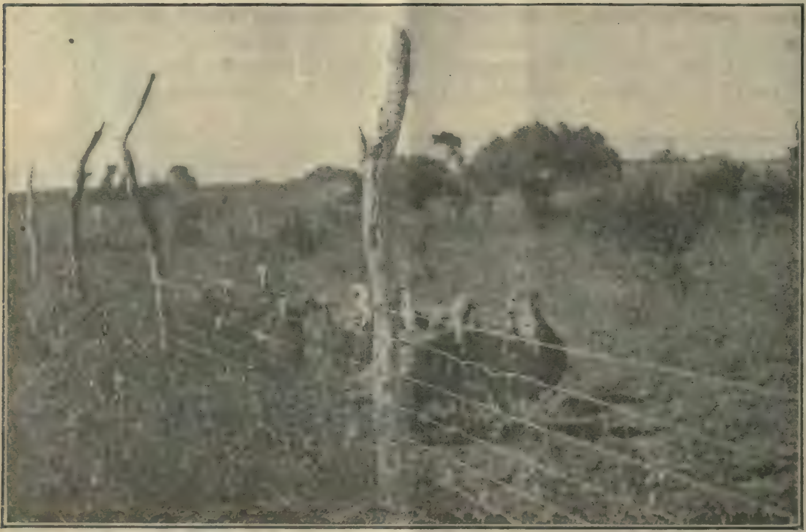

FIG. 9.—Breeding and laying pen or inclosure; hog-proof wire fence 3 feet in height.

Turkeys have not been so completely domesticated as have chickens, and it is natural, therefore, for the turkey hen to seek a secluded place to lay. One must be on the lookout for hidden nests; otherwise eggs may not be collected regularly, and they may become chilled or destroyed by predatory animals. Sometimes the hidden nest can be located by observing the turkey hen carefully as she makes her way to the nest, but a much easier and quicker method is to confine the hens early some morning soon after they come from the roost and then let them out late in the afternoon. The hens that are laying will make straight for their nests in order to lay the eggs they have been holding. Sometimes turkeys will take to nests provided for them, and whenever this is done a great deal of trouble is frequently saved. Nests are easily made of boxes or barrels, which should be so placed as to be protected from animals. (Fig. 11.)

INCUBATING THE EGGS.

There are certain factors in the incubation of turkey eggs which are very important and mean a great deal in determining the number of fully matured pullets and cockerels raised in the fall of the following year. In a large measure the criterion of success in turkey raising is the number of fully matured turkeys raised in proportion to the total number of eggs set. Therefore the eggs as laid must be given the very best attention. High fertility is desirable, and incubation should be carried out in such a way that as many of the eggs as possible will hatch. Naturally, the vigor of the breeding stock and the manner in which it has been managed will determine in large degree the quality of the hatching eggs.

The eggs should be collected regularly every day and kept in a room at a temperature of from 50° to 60° F. They should be turned every day, but should be handled carefully and should not be kept for over two weeks.

The period of incubation of turkey eggs is 28 days, and the method of incubation is much the same as with chicken eggs. Turkey eggs can be incubated under chicken hens, turkey hens, or in incubators.

If chicken hens are used to incubate turkey eggs, care must be taken not to give the hen too many eggs, as from 9 to 12 are quite sufficient, depending upon the size of the hen as well as the size of the eggs. Nesting arrangements as well as other matters are practically the same as in incubating chicken eggs. The sitting hen should be fed daily and given a chance to exercise.

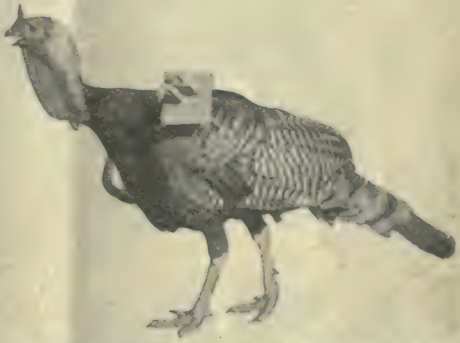

FIG. 10.—Device for preventing turkeys from flying over fence.

When the turkey hen is allowed to sit on her own eggs, conditions are much the same as with the chicken hen. Turkey hens will cover from 15 to 20 eggs. Nests are most conveniently arranged on the ground or in boxes or barrels and should be covered so that the turkey hens will not be disturbed. (Fig. 12.) At the same time they should be taken off daily and allowed to exercise and should be given plenty of water to drink and clean, wholesome feed, such as a mixture of wheat and oats.

When the turkey hen becomes broody she should be allowed to sit on the nest for two or three days before being intrusted with the eggs. When she has remained consistently on the nest for two or three days she should then be given her eggs and attended to as suggested. If a number of hens are sitting at the same time, care should be taken to see that they get back to the nests properly and that no nest is left uncovered.

Both chicken and turkey hens, while sitting on turkey eggs, should be dusted with sodium fluoride as directed on page 21. This chemical will tend to rid the sitting birds of lice which would otherwise annoy them.

The practice is becoming more common of incubating turkey eggs in incubators, the method being much the same as in the incubation of hens' eggs. Several turkey raisers have obtained best results with a temperature of 101° F. The eggs should be turned twice or three times daily and they should be tested on the tenth and twentieth days. On the twenty-seventh day the incubator door should be kept darkened and not disturbed until about the twenty-ninth or thirtieth day, because it is sometimes 30 days before the last poults have hatched.

REARING THE POULTS.

There are few problems in turkey raising so important as brooding and rearing the poults, because the greatest losses in turkey raising occur in about the first five weeks after the poults are hatched. Heavy mortality among the poults is a pretty sure indication that the breeding stock used was low in vitality or was poorly managed. Improper methods of brooding will do a great deal of harm, of course, because turkeys can not stand any great amount of dampness. They must be kept comfortable and fed properly; otherwise the digestive system may be so affected that disease will gain control.

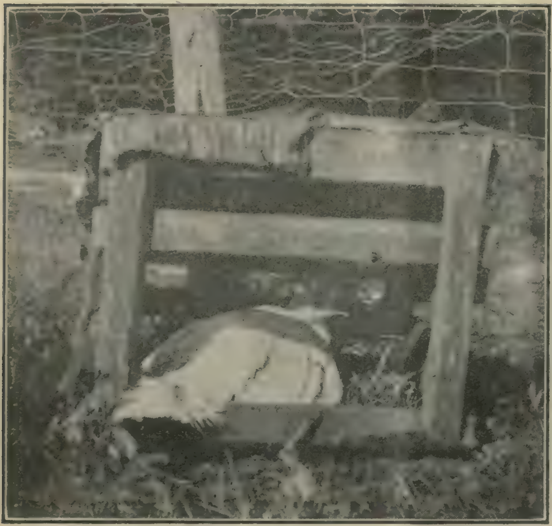

FIG. 11.—Coop used for turkey hen while sitting.

BROODING.

The poults may be brooded either by chicken or turkey hens or by artificial brooders. Brooding by hens has the advantage of enabling the poults to be raised in small flocks and of readily providing free range conditions. There is a slight disadvantage, however, in that after the hens are allowed to roam with their broods they may wander too far and some of the poults may be lost through storms or by predatory animals. On the other hand, the artificial method of brooding serves to keep down the costs and the poults are more directly under the control of the operator.

Brooding the poults by hens is not a difficult matter, although there are several details which should always receive careful attention. As soon as the hatch is completed and the poults begin to run out from under the sitting hen, the hen and her brood should be transferred to a coop. A coop of simple design, such as the **A**-shaped (fig. 13), large enough to accommodate either a chicken or turkey hen, and well built to protect the brood against the rains, is all that is required. Each hen should have a separate coop, and where there are several broods the coops should be placed some distance apart on well-drained soil where the grass is fairly short. For the first day or so it is well to confine the poults in the coop with the mother hen. Then make a small yard, using boards or wire, around the front of the coop and allow the poults to run in and out at will. Exercise is very important, but the young poults should not be allowed to run in long, wet grass, and during a heavy rain they should be confined in the coop. Plenty of exercise is absolutely essential to promote good growth. The coop should be moved to fresh ground every day. When the poults are about a week old the mother hen may be allowed to roam with her brood, but care should be taken to see that the entire brood returns in the evening and is protected for the night from predatory animals. It is especially important that the brood be properly sheltered during rainstorms or damp weather, as nothing is probably so fatal to the poults as dampness and cold. The mother hens usually remain with their broods until about October, and then the cockerels frequently leave the pullets and the sexes range by themselves.

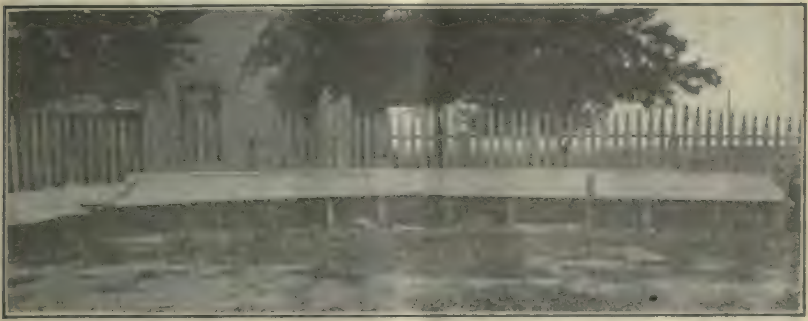

FIG. 12.—Long row of nests used by large turkey raisers for setting turkey hens.

The practice of brooding poults artificially is becoming more prevalent and in some quarters in particular is quite successful. Naturally, the broods are larger than is the case in brooding by hens. The prevailing custom is to use brooder stoves, which are placed in portable colony houses. The houses are moved frequently, thereby giving the poults plenty of free range on clean soil. The houses must be kept strictly sanitary and should be disinfected regularly. The general conditions of managing the poults are much the same as when hens are used for brooding. One point of great importance, however, in brooding poults artificially is to make sure that they do not crowd together while in the brooder house. This is avoided by keeping an even temperature and providing good ventilation. When the poults are first put in the colony house with the brooder stove the temperature under the hover should be about 98° F. 3 inches above the floor. Depending upon the season, this temperature should be lowered gradually until the poults are about 10 weeks old, when they require but very little heat, especially in the daytime. When the poults become well feathered and are inclined to roost at night, the colony house should be used as a roosting shed. Toward the approach of fall the cockerels and pullets will be inclined to roost in trees, or a covered roosting place may be constructed inclosed by a wire fence to keep out predatory animals.

DEVELOPMENT AND SEX.

The poults, when first hatched, are covered with soft down. Very soon, however, wing feathers begin to develop, and at 2 weeks of age they are long enough to cover the back, sides, and rump. When the poults are about 10 days old feathers begin to appear where the wings join the body and in about 3 weeks the tail feathers begin to appear. From then on feather growth is quite rapid, and when the poults are 2 months old they are well feathered.

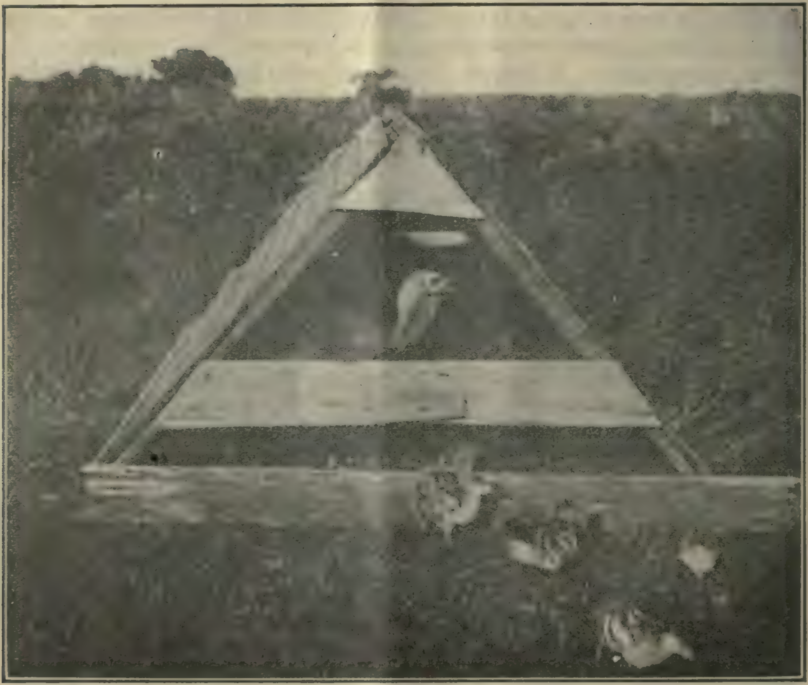

FIG. 13.—Turkey hen confined to a coop; the poults allowed to run in and out. Coop must be constructed so that the hen can not get out.

The head and upper part of the neck of mature turkeys is red and is covered with fleshy caruncles. The development of this condition is of some significance in the poults. Up to about 4 weeks of age there is no trace of red on the heads or necks. Then about the fifth week the caruncles begin to appear and by the seventh week they tend to extend down the neck. The appearance of caruncles in the poults is termed "shooting the red," and many turkey raisers believe that if they can raise their poults successfully to this stage there will be little trouble afterwards. On the top of the head in both males and females the fleshy protuberance develops into what is called the "dew bill." and in males it is larger and more elastic than in females.

The sexes of poults can be distinguished at a relatively early age by the earlier appearance of a tuft of hairs on the breast of males. The appearance of this tuft of feathers is preceded by the growth of a small, fleshy protuberance. The tuft first appears on males when they are between 3 and 4 months old, but it does not appear on the breast of females until they are about 1 year old. Then, again, the hairs of the tuft on males are much longer and coarser than those on females.

Another point of difference between adult males and females is the presence of a spur in males and its absence in females. In cockerels, or toms under 1 year of age, there appears on the inside of each shank a blunt, horny structure. As the birds grow older this develops into a stout spur. In females this horny structure remains only a rudimentary spur.

When turkeys are raised in considerable numbers, it is a good plan to adopt some system of marking them. This enables one to keep track of the different broods according to age and is of assistance in the selection of early hatched birds for subsequent breeding purposes. Also, the poults from special matings may be separated from the rest of the flock or from turkeys belonging to neighbors. The poults may be marked by clipping the toes or by punching holes in the webs between the toes. Different webs may be punched for different broods and in this way an accurate record can be kept of all turkeys raised from different matings. The poults may also be marked by using chick leg bands as in banding baby chicks. When the turkeys approach maturity wing bands may be inserted in the web of the wing, as is now done with chickens, and permanent leg bands may also be used.

FEEDING.

The feeding of the poults is a very important matter, not only from the standpoint of the kinds of feed given but also the manner in which they are fed. Unwholesome feeds and improper methods of feeding, especially where the poults are closely confined, have resulted in many failures in turkey raising. Poults kept under free-range conditions are less liable to suffer from improper methods of feeding. Under good weather conditions and where the range provides an abundance of green feed and insects the growing poults require but little extra feeding. Probably more losses result from overfeeding than all other causes. It is a good practice, however, to feed the poults regularly every night and in a short time they will return nightly to their proper roosting quarters.

While confined to the coop the mother hen should be fed twice a day on a mixture of grain, such as equal parts corn, wheat, and oats, and green feed, while water and grit should be kept before her all the time. An occasional feed of meat scrap or fresh, lean meat is greatly relished and helps to keep her in good condition. In feeding the hen and poults, it is advisable to feed the latter outside the coop and the former inside, in order to prevent her from eating the feed intended for the poults. It is seldom necessary to keep the hen and poults confined for more than a few days at a time, and the sooner all can be given free range the better. Whether or not they should all be put into the coop at night after ranging during the day depends on the weather and the danger from predatory animals.

For the first two days after hatching, poults require no feed, the yolk of the egg which they absorb before breaking out of the shell being sufficient to maintain them for that length of time. Access to clean drinking water and a little coarse sand and green feed to peck at is all that is needed until the third day. Beginning with the third day, the poults should be fed according to the quantity of natural feed they are able to pick up outside the coop. They should always be kept more or less hungry. Furthermore, the feed should never be allowed to become moldy. Feed the poults on boards; after each feeding clean off any feed that remains and stand the boards in the sun to dry. Overfeeding removes the cause of searching for food, so that little exercise is taken and indigestion is sure to result. When natural feed is scarce, or when the poults have to be kept from ranging outside, they should be fed lightly about five times a day. If allowed to run outside the coop where they can find insects, seeds, and green feed, they need not be fed oftener than two or three times a day.

Several combinations of feeds are used by different turkey raisers. The methods of feeding some of these combinations are briefly as follows:

Hard-boiled egg chopped fine and corn-bread crumbs for the first week, and then whole wheat and hulled oats.

Stale bread soaked in milk and squeezed dry for the first few days, and then common chick feed.

Clabbered milk seasoned with salt and pepper, and corn-bread crumbs.

Equal parts "pinhead" oats, whole wheat, and cracked corn.

Corn meal and wheat bran mixed in the proportion of 3 to 1 and baked into a bread.

Milk, especially buttermilk, is excellent for young poults. Buttermilk seems to be especially beneficial in bringing the poults successfully through the early stages. A good plan is to keep the milk in front of the poults during the morning and water during the afternoon.

If grit and green feed can not be picked up outside the coop, they must be provided in some other way. Chopped onion tops, lettuce leaves, dandelion leaves, and alfalfa make excellent green feed. Grit can be furnished in the form of coarse sand.

During the summer and early fall turkeys can find an abundance of feed on the average farm. Grasshoppers and other insects, weed and grass seeds, green vegetation, berries, and grain picked up in the fields all go to make up the turkey's daily ration. When this natural feed is plentiful very little needs to be added until fattening time, except for the purpose of bringing the turkeys home to roost every night and to keep them from straying from home. For this purpose one feed of grain every night just before roosting time is sufficient.

FATTENING FOR MARKET.

In fattening turkeys for market an excellent plan is to begin about the first of October to feed night and morning, feeding just enough at a time so that the birds go away still a little hungry, and gradually increasing the quantity until they are given all they will clean up three times a day during the week before marketing. Some turkey raisers feed equal parts of wheat and oats during the first part of the fattening season, gradually changing to corn as the weather becomes cooler. Most raisers, however, begin feeding heavily on corn about November 1, and since turkeys are not accustomed to such heavy feeding, scours often result, especially if new corn is used. Old corn is a much better feed than new corn, but the old corn must be free from mustiness. Nuts of various kinds, such as chestnuts, beechnuts, and acorns, are frequently available, and these make good fattening feeds. Best results in fattening are obtained when a grain ration of oats, wheat, and corn is provided.

Confining turkeys during the fattening season to prevent their using so much energy in ranging has been tried to some extent, but with little success. Those confined to a pen eat heartily for two or three days but afterwards lose their appetite and begin to lose flesh rapidly. On allowing them free range again, they pick up rapidly and are soon eating as heartily as ever. The better method is to allow them a certain amount of range, as it keeps them in good, healthy condition, and they are always eager to be fed.

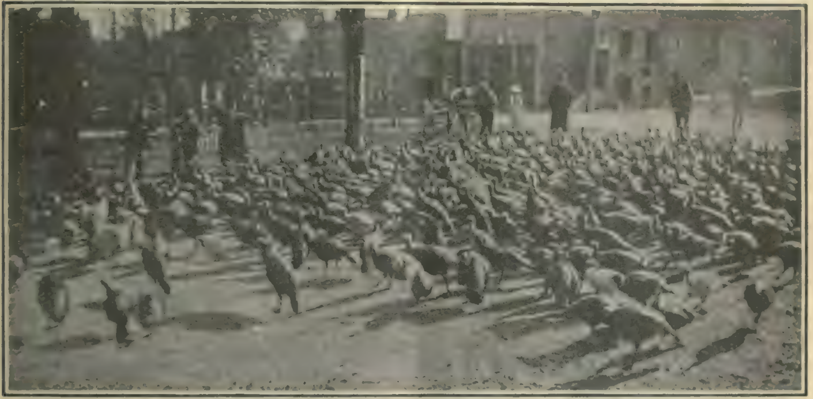

Fig. 14.—Driving turkeys to market (Glasgow, Ky.).

MARKETING.

The marketing season for turkeys is very short, running from the middle of November to the latter part of December. Many turkey raisers sell their birds alive to poultry dealers, who either dress them or ship them alive to city dealers.

In sections where turkeys are grown in large numbers, as in Texas, dressing plants have been built by poultry dealers, who buy the birds alive and dress them for the various city markets. In such cases practically all the turkey raisers sell to these dealers, who often send buyers into the country to gather up a drove of several hundred birds by stopping at each farm as they pass, weighing whatever turkeys the farmer may have to sell, and adding them to those already collected. Six or eight men can drive a flock of 1,000 turkeys 10 to 12 miles a day. (Fig. 14.) As soon as possible after the turkeys are received at the dressing plant they are killed, dry-picked, cooled, and packed in barrels or boxes for shipment.

Farmers near the city markets often dress the turkeys and sell them direct either to the consumer or to city dealers. In some sections shortly before Thanksgiving there is held what is known as "turkey day." On the day before this event every turkey grower in the neighborhood kills and dresses his turkeys and the following morning brings them into town, where they are bid on and purchased by the buyers present. (Fig. 15.)

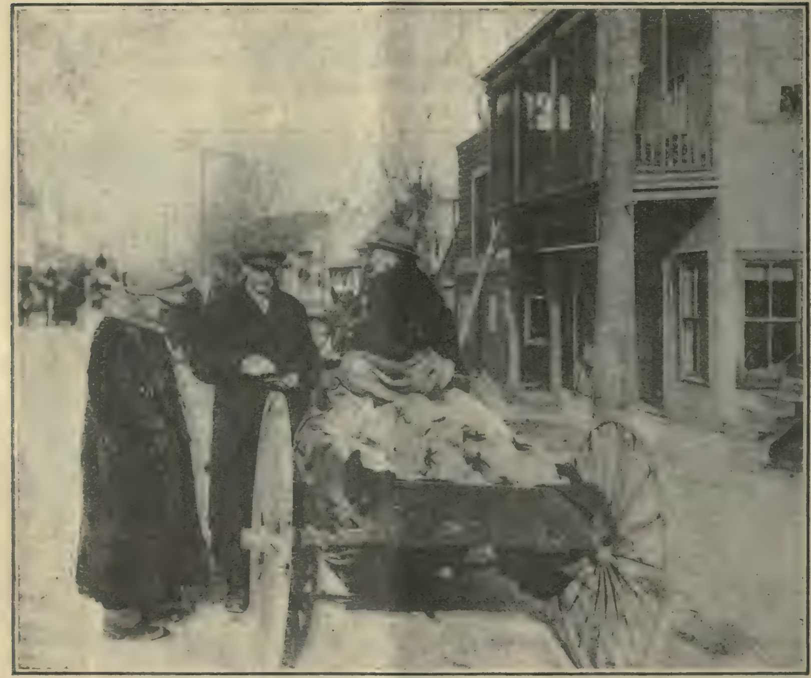

FIG. 15.—Marketing dressed turkeys on "turkey day" (Lisbon, N. Y.).

Before being killed turkeys should be deprived of feed for about 15 hours, but given plenty of fresh, clean water in order to clean the crop and intestines of all feed. When ready to be killed, the birds should be hung up by the feet. The bird's head is held in one hand and a sharp, narrow-bladed knife is used to sever the veins in the throat by making a small cut inside the mouth on the right side of the throat, at the base of the skull. After making this cut and bleeding begins, the knife is thrust up through the groove in the roof of the mouth and into the brain at the back part of the skull. When the brain is pierced, the bird gives a peculiar squawk, the feathers are loosened by a quivering of the muscles, and death is instantaneous. In dry picking the feathers should be plucked immediately, and if the bird has been properly stuck they come out very easily.

The tail and large wing feathers are removed first, after which the body feathers are pulled out.

When the turkeys are to be marketed locally or shipped but a short distance they are cooled to a temperature of about 35° F. by hanging in the open air, provided the weather is cool enough; otherwise they are plunged into ice water and kept there until thoroughly cooled. After cooling they are packed undrawn in boxes, or barrels. There is considerable risk for the producer without proper refrigerating facilities in shipping dressed turkeys long distances, as losses from improper cooling and from their being exposed to warm weather during transit are liable to occur. These losses may be reduced by packing the birds in barrels with cracked ice between layers of turkeys and at each end of the barrel. A top layer of ice placed between two layers of burlap tacked securely over the top of the barrel is desirable. When turkeys are shipped any great distance in carload lots, they are usually cooled to 32° F., packed in boxes or barrels, and shipped in refrigerator cars.

Turkey feathers, when properly prepared, command good prices and are quite valuable. Feathers from birds that have been scalded, however, are hardly marketable, and this is one of the principal reasons why turkeys should be plucked dry. The feathers are used for various purposes, such as feather dusters, feather beds, and pillows. After the turkeys have been plucked, the feathers should be collected and thoroughly aired and dried. Separate the quill feathers from the others; sometimes it pays to separate the white feathers from the colored ones. The animal heat must be allowed to pass out, and the feathers should be quite dry. When they are spread out to dry they should be turned frequently. Be sure all feathers are thoroughly cured and dry before being packed in strong burlap sacks for shipment to market.

DISEASES, AILMENTS, AND PARASITES.

Avoidance of parasites and prevention of disease should be the first aim of every turkey raiser. Good management will keep the flock rid of parasites, and the selection of breeding stock having abundance of constitutional vigor will help materially in preventing disease. Turkeys should always be given the best possible surroundings. Provide free range on clean (sanitary) soil; feed wholesome foods on clean soil; provide plenty of green feed; give the stock good protection from dampness; keep the quarters strictly sanitary at all times; then, finally, breed for more constitutional vigor.

BLACKHEAD.

Of the infectious diseases among turkeys, blackhead is the most destructive. This disease first became serious in the New England States many years ago, and it is now found to a greater or less extent throughout most parts of the United States. Blackhead occasionally affects adult turkeys, but it occurs principally among young turkeys between the ages of 6 weeks and 4 months.

The symptoms are such that unless the bird is killed and an examination of the internal organs made it is difficult to tell whether the disease is blackhead or some other ailment. The head of the turkey sometimes turns dark, and it is from this symptom that the name blackhead originated; this is an unfortunate term, as the head often does not turn dark, and even though it does it merely indicates that the bird is sick from some ailment that may or may not be blackhead. The bird drinks a great deal, but refuses to eat and grows steadily weaker until its death, which usually occurs a few days or a week after the sickness is first noted. Diarrhea commonly occurs and the droppings vary in color from white to brown, but are usually a bright yellow. On opening a turkey that has died of blackhead, one or both of the ceca or " blind guts " are found to be enlarged and plugged with a cheesy material and the liver is more or less covered with spots varying in color from grayish-white to yellow.

Apparently no positive cure for blackhead has been found. As in the case of all other infectious diseases, to prevent further spread of the disease, the sick bird should be removed from the flock immediately and if very sick should be killed and the body burned. Clean out the roosting place and spread lime in places most frequented by the turkeys. Keep a disinfectant in the drinking water; potassium permanganate is most often used, a sufficient quantity of the crystals being added to give the water a wine color, which, for every gallon of water, will take about as much of the chemical as can be placed on a dime. If the turkeys are being fed heavily, their ration should be reduced, as overfeeding predisposes to the disease. The feeding of sour milk has been found of advantage in keeping turkeys in good health and in reducing the activities of the organism causing blackhead. Free range and care not to overfeed are most important.

By all means possible prevent the introduction of blackhead into the flock, but if it once gets into the flock then do everything possible to prevent its spread. Several measures of prevention may always be taken as a precaution, the chief of which are: Obtaining eggs from flocks believed to be healthy; disinfecting the eggs to be incubated with a cloth soaked in an 85 per cent solution of alcohol; keeping the poults on ground at a distance from all other fowls; excluding, as far as possible, pigeons, sparrows, and other animals from the turkey houses and yards; frequent disinfection of houses, feed troughs, and all equipment; the immediate killing and burning of all affected birds.

ROUP.

Turkeys are sometimes affected by roup, a disease very common among chickens, particularly when they are exposed to drafts and dampness. The first symptoms of roup are those of a common cold; later a swelling usually develops just below the eyes, giving rise to the name " swell head." Roup is very contagious, and any infected bird should be isolated and the mouth and nostrils washed out with an antiseptic. If there is a swelling under the eyes, it should be opened and the material that has formed there squeezed out; also, the cavity should be washed with an antiseptic. Hydrogen peroxid used without dilution is good for this purpose.

In most cases it is advisable to kill any bird sick with anything of a contagious or infectious nature rather than to attempt treatment and run the risk of spreading the disease. All birds killed should be burned.

CHICKEN POX.

Chicken pox (sore head) is quite often found among turkeys, particularly when they are raised with fowls. It is characterized by scabby eruptions about the head and spreads quite rapidly from one bird to another. The affected birds should be removed from the flock, the scabs soaked off with warm water, and the sores painted with iodin or washed with an antiseptic such as a 2 per cent solution of carbolic acid or of potassium permanganate. Treatment with Lugol's solution, followed by an application of powdered iodin, is very effective. Watch carefully for any sores appearing on the heads of the turkeys and isolate and treat such birds immediately. Then go over the rest of the flock; rub Lugol's solution over the head and upper part of the neck of every bird and next apply powdered iodin. There should be no further trouble, particularly if the affected birds are not returned to the flock until completely cured.

LIMBERNECK.

Limberneck is characterized by a paralysis of the muscles of the neck, caused by the absorption of poison from the intestines. The presence of these poisons is usually due to eating decayed meat or moldy grain, or it may be attributed to indigestion or intestinal worms. A tablespoonful of castor oil to which 15 drops of oil of turpentine have been added should be administered.

IMPACTION OF THE CROP.

Impaction of the crop is caused by eating indigestible substances, such as feathers or dry grass, and thus preventing free passage of the feed. The crop can usually be emptied by first giving a teaspoonful of sweet oil and then working the contents of the crop with the fingers up through the gullet and out of the mouth, the bird being held with its head down.

LICE.

Lice are among the most important causes of the high mortality among young poults, those badly infested becoming gradually weaker and weaker until they die. Head lice cause most of the trouble and are found close to the skin under the top of the head, above and in front of the eyes, and under the throat. Small white lice are also found along the wing bar, among the quills of the feathers and occasionally are found below the vent. By applying an insect powder, such as sodium fluoride, when the hen is set, it is a very easy matter to prevent lice from getting a start among the poults. If this is not done the poults are almost certain to have lice. The sodium fluoride should be applied among the feathers next to the skin, one pinch on the head, one on the neck, two on the back, one on the breast, one below the vent, one at the base of the tail, one on each thigh, and one scattered on the underside of each wing when spread. The poults should be examined carefully every few days, and if lice are found about the head a small quantity of lard should be rubbed over the affected parts. This kills the lice by closing their breathing pores. Sodium fluoride should also be used on the poults if body lice are found, but should not be applied until the poults are at least a week old, and then only two very small pinches should be used. One of these should be distributed on the neck, top of head, and throat, and

APR 13

the other on the back and below the vent. Every precaution should be taken to keep down lice, especially on poults, because they cause enormous losses if not kept in control.

WORMS.

Turkeys are frequently troubled with worms. The irritation of the intestinal wall caused by worms may give rise to disease. There are principally two kinds of worms that infest turkeys, the roundworm and the cecum worm. Both are difficult to get rid of, but clean soil and regular disinfecting will help to keep them down.

It is a good plan to give the turkeys a light feeding of sulphur mixed with the moist mash. This will tend to keep down worms and help to keep the turkeys in good health. Another good plan is to put tobacco dust in the mash, to the extent of about 2 per cent of the dry mash. Where birds are badly infected a common method of treating is to give 2 grains of santonin to each bird. Dissolve the santonin in water and use to mix the wet mash.

SUMMARY.

To be successful in turkey raising, one must give the most careful consideration to certain fundamental factors. The turkeys, especially the growing stock, must be kept under the best possible conditions.

Free range seems indispensable, although there are a few who have made a success in raising turkeys in confinement. A more thorough test of this method is necessary, however, before it can be advocated. Certainly abundance of free range on clean soil is greatly to be preferred. Every effort should be made to keep the soil sweet and clean. This is particularly true of the soil on which the birds are fed and where they roost.

Another fundamental essential is to keep healthy and vigorous breeding stock in the best possible breeding condition. The breeders should get plenty of exercise and should not be fed too heavily on fattening rations. The great difficulty is to get stock that is free from blackhead, but one can at least select breeding stock based on constitutional vigor. By breeding from the most vigorous birds every year, a flock of healthy stock may be developed and maintained. Certainly much more care should be exercised in the selection of male breeders each year.

Both old and young turkeys should be protected from dampness. In sections of the country where dampness is prevalent or where rainstorms are frequent the birds should be provided with suitable protection.

It is very important not to feed the poults too heavily, especially for the first few weeks. Keep them just a little hungry.

Watch the poults carefully for the appearance of lice and take every precaution to keep them in check. Disinfect the brooding quarters regularly as well as the poults and examine them from time to time to see that they are not suffering from the pernicious lice, which sap their vitality to a large extent.

As far as possible remove the cause of any disease that might appear. Clean soil, sanitary quarters, and hygienic methods of feeding will do much to reduce mortality. Success in turkey raising is largely a question of proper management.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1924

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1410

CONTROL OF BROWN-ROT OF PRUNES AND CHERRIES IN THE PACIFIC NORTHWEST

A prune mummy with attached apothecia

BROWN-ROT is found annually in the prune and cherry orchards of the lower Columbia and Willamette Valleys, both as a blossom infection and a rot of the fruit.

In most years the losses are small, but occasionally, when unusually damp weather prevails, there is a serious epidemic, which causes the loss of a large percentage of the crop, sometimes by destroying the young fruit in the blossom stage but more often by the development of rot as the fruit approaches maturity.

Fall and winter plowing and thorough cultivation during the blooming season greatly decrease the blossom infection.

Thorough pruning aids in the control of brown-rot and is otherwise valuable in producing the crop.

For the complete control of brown-rot, spray the trees just before the blossoms open, just after the petals have fallen, when the husks are shed, and three to five weeks before harvest. The last application has been found particularly valuable on prunes.

Lime-sulphur has caused considerable injury to foliage on both prunes and cherries. Bordeaux mixture and self-boiled lime-sulphur sometimes have had a dwarfing effect on the sweet-cherry fruit.

Washington, D. C. Issued March, 1924

CONTROL OF BROWN-ROT OF PRUNES AND CHERRIES IN THE PACIFIC NORTHWEST.

By **D. F. Fisher** and **Charles Brooks**, *Pathologists, Office of Fruit-Disease Investigations, Bureau of Plant Industry.*

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OCCURRENCE OF BROWN-ROT.

BROWN-ROT of prunes and sweet cherries annually attacks orchards in the lower Columbia and Willamette Valleys. In most years the attacks are not severe enough to attract general attention, but occasionally the constantly present disease breaks out into a serious epidemic that causes the loss of a large percentage of the crop. The destructive phases of the disease have taken two

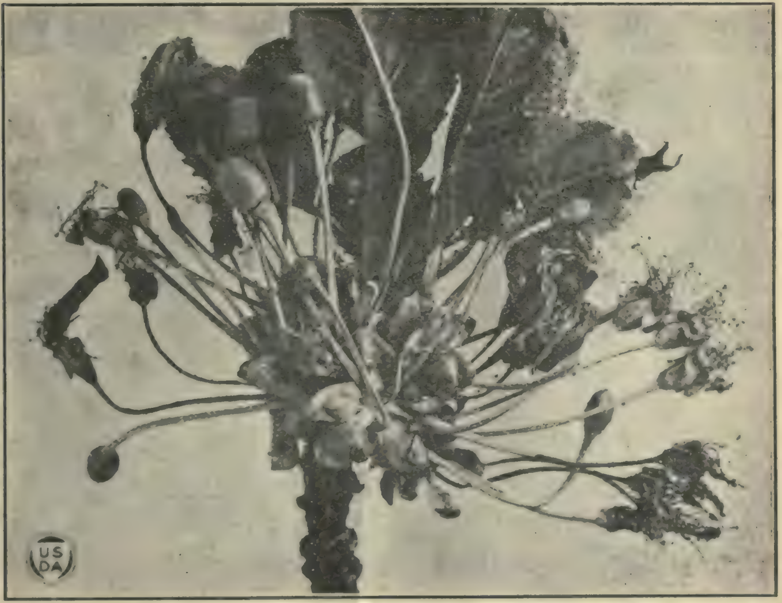

FIG. 1.—Brown-rot infection on young Napoleon cherries, from Felida, Wash., in 1916.

forms—one an infection of the blossoms and the other a rotting of the fruit as it approaches maturity.

BLOSSOM INFECTION.

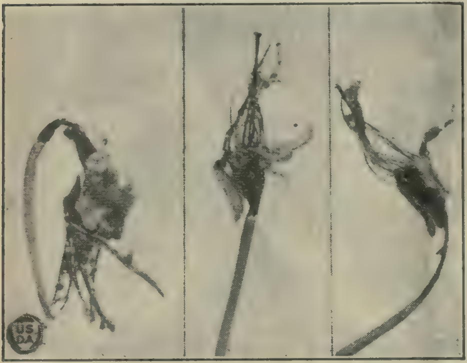

FIG. 2.—Young Italian Prunes affected with brown-rot. Collected at Felida, Wash., April 9, 1915.

Blossom infection is often overlooked, yet it represents the first foothold the disease gets in the orchard in the spring. The trouble usually starts as a browning or blackening of the under calyx lobe and may later spread to such an extent as to involve the whole flower and part or all of its stem. The blackened parts usually persist for a considerable time, furnishing a ready means of distinguishing the diseased blossons from those that are yellowing from a lack of pollination or from starvation. (Figs. 1, 2, 3, and 4.) In some years there is but little blossom infection, while in others from a third to two-thirds of the blossoms are destroyed by the brown-rot fungus, the severity of the epidemics varying greatly with the weather conditions and with the cultural and spraying practices.

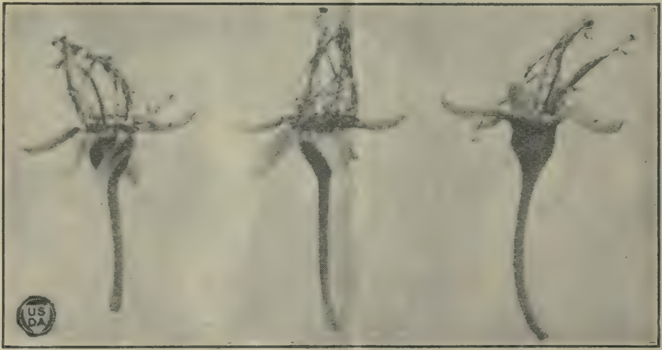

FIG. 3.—Healthy prunes collected at the same time and place as those shown in Figure 2.

FRUIT INFECTION.

The prunes and cherries may become infected with brown-rot at any time during the season, but they are much more susceptible as they approach maturity. If damp and showery weather prevails during harvest time, there is likely to be a rapid spread of the disease. (Figs. 5 and 6.)

In some years, as much as a third of the total crop is destroyed while still on the trees; and even under average conditions the losses in the more neglected orchards are usually heavy. When dry weather prevails throughout the harvesting period, the orchard losses are small, and brown-rot becomes a menace only when the fruit is shipped or is delayed at the drier or cannery.

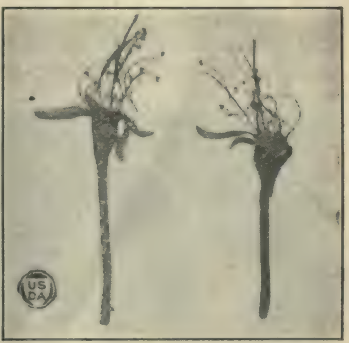

FIG. 4.—Yellow and apparently unpollinated prunes collected at the same time and place as those shown in Figures 2 and 3.

THE BROWN-ROT FUNGUS.

The brown-rot fungus[1] lives through the winter on the rotten and mummied fruit that is left on the tree or on the ground. The prunes and cherries that are partly buried in the trash or soil are most favorably situated for carrying the disease over.

The fungus develops a mass of tissue within the rotten fruit, and about blooming time sends up urn-like growths known as apothecia. (Figs. 7 and 8.) The top of the apothecium is exposed above ground, the length of its stem varying with the depth at which the mummy is buried. The stem sometimes attains a length of 5 inches. At first the enlarged top is cup shaped, but later it flattens into a more or less disklike body. If the mature apothecium is jarred, spores are thrown out like a puff of smoke. These spores are carried to the blossoms by the wind, and they germinate there to start the

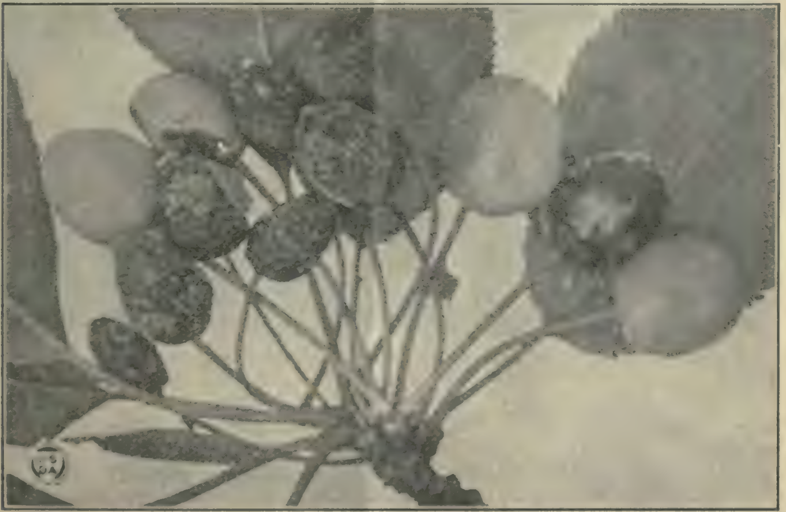

FIG. 5.—Immature Napoleon cherries affected with brown-rot. May 25, 1915.

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[1] *Sclerotinia cinerea* (Bon.) Wor.

fungus anew. (See figs. 1 and 2.) The blossom is killed, and a few days later powdery ash-gray masses may be found on its surface.

These powdery masses are made up of summer spores that serve to spread the disease in the orchard.

If the weather is damp, these summer spores germinate on the surface of the prune or cherry, sending out threads that penetrate the skin and start the rot.

When a particular rot is well advanced, ash-gray spore masses appear on its surface, which serve in turn for a further spread of the disease. (See figs. 5 and 6.) When the fungus has once penetrated the skin of the fruit, spraying or other orchard treatment can not prevent development of rot. Low temperatures greatly delay the growth of the fungus and may be used to great advantage with the harvested fruit as a preventive for losses from brown-rot.

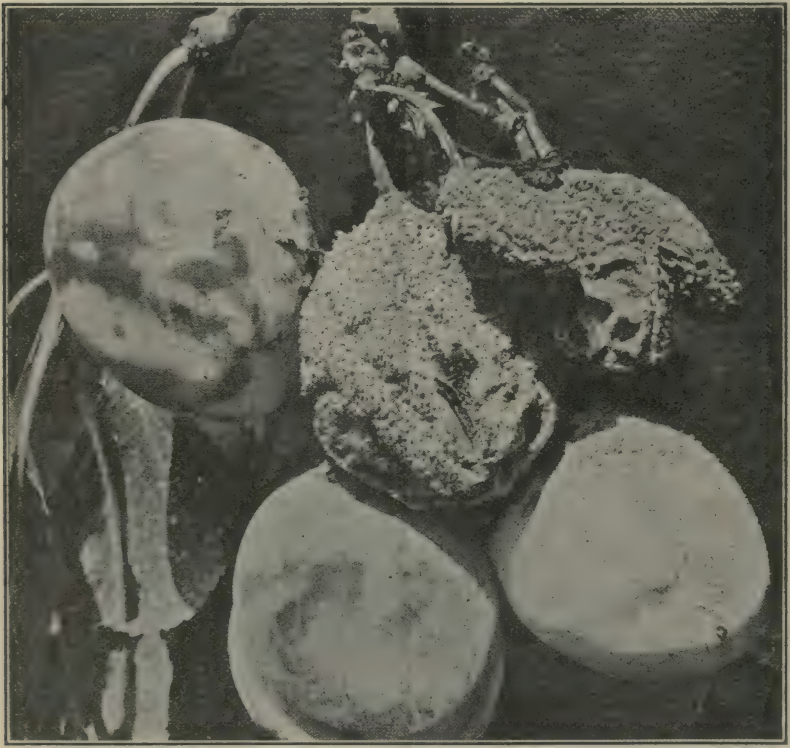

FIG. 6.—Italian Prune plums affected with brown-rot. Photographed when the fruit was beginning to color, August 11, 1915.

PLOWING, CULTIVATION, SOILS.

Plowing and harrowing are of great value in the control of brown-rot. Fruit that is deeply buried is not likely to produce apothecia. Harrowing, in the early spring and during the blossoming season is likely to disturb the partly formed apothecia and prevent their further development. Orchards that are not plowed or cultivated until after the blossoming season, as is frequently the practice, usually have an abundance of apothecia, while those that are plowed and cultivated before that time are usually practically free from them, except in tree rows or other unplowed areas. Apothecial clusters sometimes have been found, three or more to the square foot, in the uncultivated tree-row strips and entirely absent in the cultivated parts of the orchard.

Different soils are not equally favorable to the development of apothecia. They occur on moist bottom lands more abundantly than on well-drained hills. They are hardly ever found on coarse, "red-shot," clay soils.

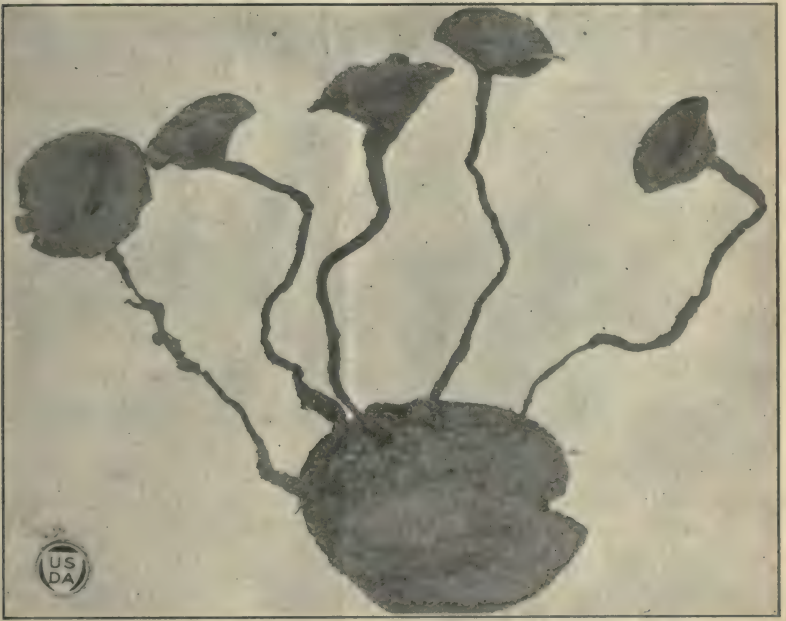

FIG. 7.—Italian Prune mummy and attached apothecia, from the orchard of A. W. Moody, Felida, Wash., April 9, 1915.

Orchards free from apothecia, made so through cultivation or otherwise, have been found to be free from blossom infection and usually relatively free from brown-rot.

SPRAYING FOR PRUNE BROWN-ROT.

The conclusions in regard to spraying are based on experiments carried out in the Italian Prune orchards of A. W. Moody at Felida, Wash., during the years 1915 to 1918, inclusive, and in the Italian Prune and Agen Prune (*Petite Prune*) orchards of L. T. Reynolds at Salem, Oreg., in 1916 and 1919. These experiments will be reported in detail in a forthcoming department bulletin.

Blossom infection was always reduced by early applications of spray. In some cases the resulting benefits were apparently lost in the June drop, but in others the sprayed trees carried a much heavier load at picking time than those that were not sprayed.

During the five years covered by the experiments, brown-rot of the fruit was never severe in the orchards in which the experiments were made, but the contrasts between the sprayed and unsprayed trees showed that the spray applications had been very efficient in holding the disease in check. A summary of the five years' results is shown graphically in Figure 9. It will be seen that the sprayed fruit had only about one-third as much brown-rot at harvest time as the unsprayed and that in the shipping and holding tests it developed only one-fourth as much disease as the unsprayed fruit.

A spray a few weeks before harvest was found to be particularly valuable for controlling the brown-rot. This fact is brought out in Figure 10, which gives a graphic summary covering this phase of the spraying results. Approximately one-half the brown-rot control was due to this late spraying.

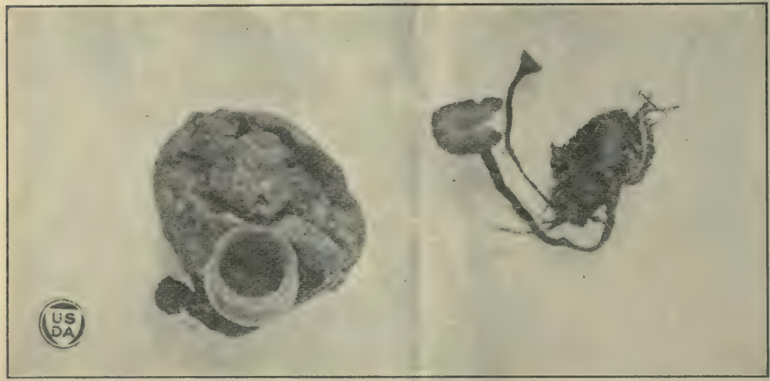

FIG. 8.—Black Republican cherry mummy and attached apothecia, from the orchard of L. T. Reynolds, Salem, Oreg., March 31, 1916.

Sulphur dust has given approximately as good brown-rot control as the standard spray materials. A summary of spraying and dusting results is shown in Figure 11.

RECOMMENDATIONS FOR THE CONTROL OF BROWN-ROT OF PRUNES.

The prune brown-rot problem in the lower Columbia and Willamette Valleys is apparently not so much a matter of finding remedies as a question of how much money and effort the grower is justified in spending and is willing to spend on a disease that is more or less erratic in occurrence. There seems to be no doubt that the remedial measures that have become fairly well established in sections of the eastern United States, where brown-rot is more constant in its occurrence, would fully meet the situation in the humid sections of the Pacific Northwest if consistently applied. The question is really one of balancing the cost of insurance against the possibility of loss and determining the most economic procedure.

Cultivation can be recommended as a good investment. Plowing in the fall, winter, or early spring and frequent harrowing before and during the blooming season will decrease the number of apothecia.

Many of the orchards of this section need heavier pruning. A proper thinning out and cutting back of the top encourages renewal of fruiting wood, gives a better set of fruit, and helps to prevent brown-rot by admitting the sunlight and by giving an opportunity for thorough spraying.

The application of dust or spray three to five weeks before harvest can be recommended as an insurance fully justified by average conditions. The advisability of spraying just before the blossoms open, just after the petals have fallen, and just after the husks are shed may vary with the orchard and the season; but applications are timely in all cases where brown-rot is likely to become a menace.

The effectiveness of any spray material depends very largely on the thoroughness of the application, the fineness of the spray, and the manner in which it covers and adheres. The smooth, waxy skin of the prune renders it practically impossible to effectively cover and protect the fruit with any liquid material without the addition of a spreader.

Various spreaders have been tested for use on prunes, and of these the resin-fishoil soap and casein have proved most satisfactory. The resin-fishoil soap causes considerable foaming in the tank and is somewhat objectionable on this account. It is more troublesome to make and more expensive than the casein. For directions on preparing spreaders, see page 11.

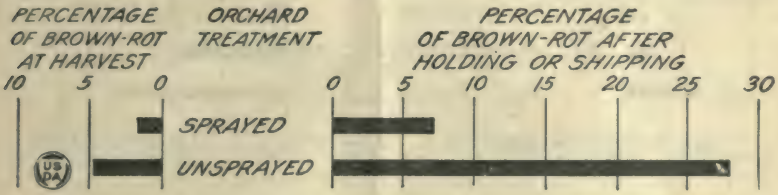

FIG. 9.—Comparison of the average development of brown-rot on sprayed and unsprayed Italian Prunes in 11 different spraying and holding experiments.

Both lime-sulphur and Bordeaux mixture caused more or less spray injury, the former in particular. Bordeaux injury was always associated with rainy weather following the spraying, while lime-sulphur injury was associated with hot weather. Because of the possibility of serious spray injury lime-sulphur is not recommended for prunes. Self-boiled lime-sulphur, 8–8–50, is to be preferred to Bordeaux mixture. For directions on preparing sprays, see page 8.

RECOMMENDATIONS FOR CONTROL OF BROWN-ROT OF SWEET CHERRIES.

The conclusions in regard to spraying sweet cherries are based on experiments in 1915 to 1919, inclusive, in the orchards of L. T. Reynolds at Salem, Oreg., on the Napoleon (*Royal Ann*), Black Republican, and Lambert varieties. The results will be reported in detail in a forthcoming department bulletin.

Under the climatic conditions of the lower Willamette Valley sweet cherries were found susceptible to spray injury. Lime-sulphur frequently caused some injury to the foliage, and Bordeaux mixture and self-boiled lime-sulphur usually had a more or less dwarfing effect on the fruit.

The addition of resin-fishoil soap to the spray material tended to decrease the cracking of the fruit that sometimes occurs in showery weather.

Early spray applications reduced the amount of blossom infection (fig. 12), but the set of fruit was usually so nearly evened up in later "drops" that there was little difference in yield between the sprayed and unsprayed trees.

During the five years that the tests were continued practically no brown-rot was seen in the orchards at picking time, and any conclusions as to the merits of spraying have to be based on the holding quality of the fruit. The summary of results from 18 different holding tests given in Figure 13 shows that the sprayed cherries developed less than a third as much brown-rot as those unsprayed.

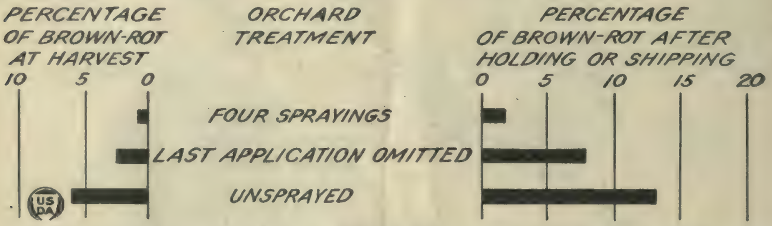

FIG. 10.—Brown-rot control of prunes as influenced by an application of spray or dust three to five weeks before picking time. The diagram shows the average results obtained from 7 orchard experiments and 11 holding tests.

The last spraying was the most important one, with reference to development of brown-rot on the harvested fruit. A summary of the tests on this point is given in Figure 14.

The five years' investigation has not furnished a basis for definite recommendation in regard to brown-rot of cherries as it occurs in the lower Willamette Valley. Fall or winter plowing and early spring harrowing, both in the cherry orchards and adjacent prune orchards, undoubtedly would be of value in reducing the amount of disease on the blossoms. Spraying has greatly reduced the amount of brown-rot developing after picking. But in view of the small percentages of rot that have occurred in the orchards, and the prevailing custom of disposing of all the sweet cherries at the cannery, it may be a question whether systematic spraying would pay.

PREPARATION OF SPRAYS.

SELF-BOILED LIME-SULPHUR.

The standard self-boiled lime-sulphur mixture is composed of 8 pounds of fresh stone lime and 8 pounds of sulphur to 50 gallons of water. Any finely powdered sulphur—flowers, flour, or commercial-ground sulphur—may be used.

To get the best action from the lime, prepare the mixture in rather large amounts, at least enough for 200 gallons of spray, which calls for 32 pounds of lime and 32 pounds of sulphur.

Place the lime in a barrel. Pour on enough water to almost cover it, which probably will take about 6 gallons. As soon as the lime has well started to slake, add the sulphur, after first running it through a sieve to break up the lumps and mixing it to a slush with a little water. Stir the mixture at intervals, and add more water, 3 or 4 gallons, as needed, to form a moderately thick paste. Cover it and allow to stand four to five minutes. If on slight stirring it is found to be growing thinner and softer and the light sulphur yellow changing to a brownish color, the process is finished, and cold water should be gradually stirred in.

If after four or five minutes the mass has not softened or darkened distinctly on testing with the paddle, it should be immediately covered and allowed to stand another four or five minutes. Repeat this until the mixture is softer and darker in color, and then check the action by adding cold water.

The mixture is then ready to be strained into the spray tank, diluted with water, and used.

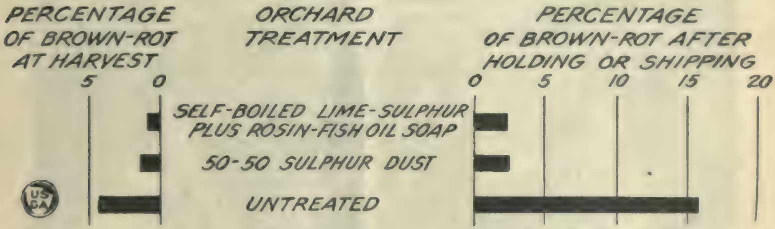

FIG. 11.—Comparative results from spraying and dusting in a four-year test on prunes.

If the mixture is allowed to remain hot for 15 or 20 minutes after slaking is completed, part of the sulphur probably will go into solution, combining with the lime to form sulphids. The resulting spray has greater fungicidal value and is preferred for use on prunes but may be injurious to peach foliage. The stage at which the cold water should be added to stop the cooking varies with the lime. Some limes are so sluggish in slaking that it is difficult to obtain enough heat from them to cook the mixture at all, while other limes become intensely hot on slaking, and care must be taken not to allow the boiling to proceed too far. After using self-boiled lime-sulphur, it is important to thoroughly wash the spray tank and pump to remove the sediment.

BORDEAUX MIXTURE.

Bordeaux mixture is made of copper sulphate (bluestone), lime, and water. As ordinarily used for brown-rot of prunes, it consists of 4 pounds of copper sulphate, 4 pounds of stone lime, and 50 gallons of water.

It is convenient to make up stock solutions of copper sulphate and lime in 50-gallon lots.

A stock solution of copper sulphate is made by dissolving it at the rate of a pound of the copper sulphate to a gallon of water, 50 pounds of copper sulphate being placed in a clean gunny sack and suspended just beneath the surface of 50 gallons of water in a barrel (one with wooden hoops being preferable). This will dissolve in 24 hours, or sooner if hot water is used. A gallon of this stock solution then contains 1 pound of copper sulphate.[2]

The lime is prepared by slaking a definite quantity of stone lime (it should be at least 90 per cent pure) in a measured quantity of water. A smoother paste and a better spray mixture will be obtained if the slaking is begun with hot water, and hot water is often necessary where slow-slaking lime is used. If hot water is used there is also less danger of "drowning" the lime. If cold water is used, the action should be started by adding only enough water to cover the lime. As the lime begins to slake it takes up water and more must be added. Stir until a paste is formed, then add the remaining quantity of water. If 50 pounds of lime is used, add water to make 50 gallons of stock solution, 1 gallon of which, when thoroughly stirred, then holds 1 pound of lime. After preparation cover the barrels to prevent evaporation, if the material is not to be used at once.

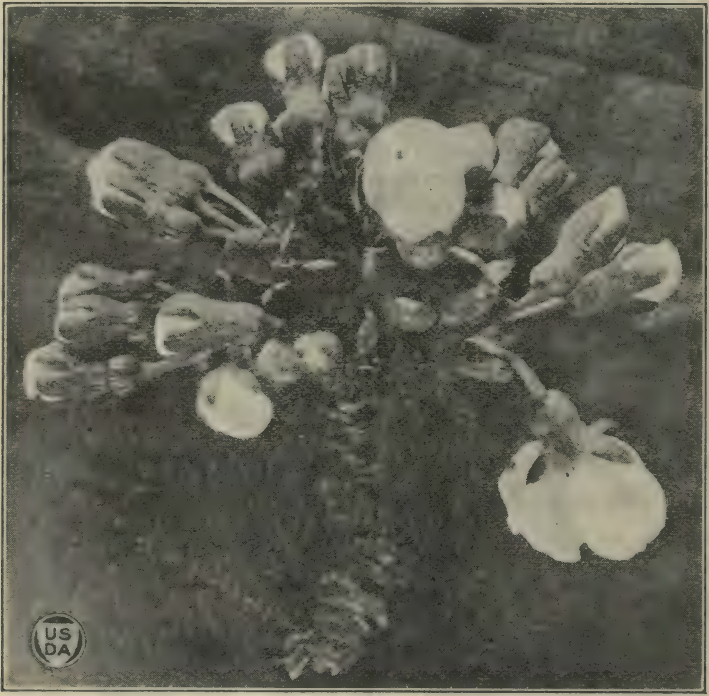

FIG. 12.—Napoleon cherry blossom cluster, showing the stage of blooming when the first spraying should be made.

One point to keep in mind in preparing Bordeaux mixture is—never mix strong stock solutions together. Put into the spray tank the right amount of either one of the stock solutions, then run in some water, start the agitator, and put the other stock solution in.

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[2] Always stir the stock solution before dipping any out.

If the strong copper-sulphate stock solution is put in first, it is possible to remove the coarse particles of lime from the stock lime solution by washing it through the sieve while filling the tank. The spray tank and pump should be thoroughly washed with clean water after Bordeaux mixture has been used.

LIME-SULPHUR SOLUTION.

Commercial preparations of lime-sulphur solution are usually obtainable on the market. They have largely taken the place of the homemade solutions. The commercial article is reasonable in price, as a rule, and more uniform in strength than the homemade; and spraying is simplified by its use, since all that is necessary to prepare the spray is to dilute the commercial concentrate with the required quantity of water.

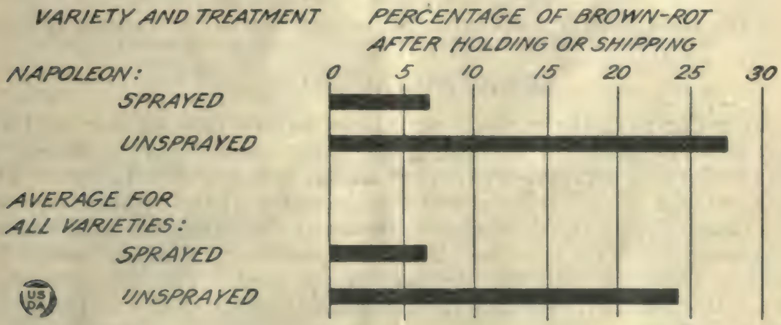

FIG. 13.—Comparison of the average development of brown-rot on sprayed and unsprayed cherries in 18 different holding and shipping tests.

RESIN-FISHOIL SOAP.

Resin-fishoil soap may be made up as follows:

Rosin	5 pounds.
Potash lye (such as is sold for washing purposes)	1 pound.
Fishoil	1 pint.
Water	5 gallons.

Dissolve the resin in the oil by heating in a large kettle. After this has partly cooled, add the potash. Slowly stir the mixture and watch it carefully to prevent boiling over. Now add part of the water and continue the boiling until the mixture will dissolve in cold water. This will require about an hour. Then slowly add the rest of the water and stir the mixture thoroughly. For use, add 1 quart to 200 gallons of spray.

CASEIN.

Commercial caseinate spreaders may be bought, but an equally satisfactory product can be made at home. To prepare a casein spreader, proceed as follows:

Casein	1 pound.
Baking soda	3 ounces.
Water	1 gallon.

Mix the ingredients thoroughly. Let stand for at least an hour before using. To use, add 1 quart of the casein solution to 200 gallons of spray.

If the casein is of coarse granular consistency, substitute caustic soda (ordinary lye) for the baking soda, and put it in the water first. Then heat this soda solution to the boiling point, and add the casein slowly while stirring carefully to prevent formation of lumps. To use the resulting solution, dilute 1 quart to 200 gallons of spray. These liquid casein preparations do not keep well, and consequently no more should be made than will be used for a particular application.

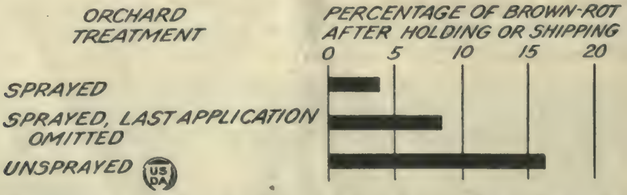

FIG. 14.—Development of brown-rot on the harvested cherries as influenced by a late spray application (about three weeks before picking time).

SPRAYING SCHEDULE.

In order that the grower may have before him in concise form the recommendations for spraying prunes and cherries offered in this bulletin, a condensed spraying schedule is given in Table 1. The first column of this table shows the character of the application and the time of applying it, stated in terms of the condition of the trees. The second column specifies the most satisfactory spray material for prunes, together with the strength to be used. The third column, in similar manner, specifies the most satisfactory spray material for sweet cherries.

TABLE 1.—*Spray schedule for control of brown-rot on prunes and sweet cherries in western Washington and Oregon.*

Application and time.	For prunes.	For sweet cherries.
First brown-rot spray (bud spray). Apply when blossom buds are white and before full bloom. (Fig. 12.)	**Bordeaux mixture, 4-4-50.** **Lime-sulphur, 1 to 50.** Self-boiled lime-sulphur, 8-8-50. Sulphur dust.	**Bordeaux mixture, 4-4-50.** **Lime-sulphur, 1 to 50** Sulphur dust.
Second brown-rot spray (calyx spray). Apply as soon as most of the petals have fallen.	**Bordeaux mixture, 4-4-50.** **Lime-sulphur, 1 to 50.** Self-boiled lime-sulphur, 8-8-50. Sulphur dust.	**Bordeaux mixture, 4-4-50.** **Lime-sulphur, 1 to 50.** Sulphur dust.
Third brown-rot spray. Apply as soon as husks are shed.	**Self-boiled lime-sulphur, 8-8-50.** Bordeaux mixture, 4-4-50. Sulphur dust.	Lime-sulphur, 1 to 50. Sulphur dust.
Fourth brown-rot spray. Apply two to three weeks before fruit is ripe.	**Self-boiled lime-sulphur, 8-8-50.** Bordeaux mixture, 4-4-50. Sulphur dust.	Lime-sulphur, 1 to 50. Sulphur dust.

The more important applications are printed in heavy type. The more effective and safest spray materials for each application are likewise indicated, where any difference has been shown to exist. A spreader should be combined with the fungicide in each application, particularly the third and fourth. Casein spreaders may be used with any of the sprays above mentioned, but resin-fishoil soap can not be used with lime-sulphur.

This entire schedule is required for complete insurance against brown-rot, and it may be necessary occasionally to put on an emergency application in unusually damp and rainy weather.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

February 27, 1924.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1411

CRIMSON CLOVER

SEED PRODUCTION

CRIMSON-CLOVER SEED for home use can be readily saved with homemade machinery.

A simple type of comb stripper is the best for the average farmer, though suction strippers have been successful.

For commercial growing, hullers are necessary, and the crop is usually cut with a mowing machine.

The best yields of seed are secured from the poorer soils, as on soils rich in nitrogen the plants grow too rank.

Commercial seed is grown most largely in Tennessee, but some is produced in Delaware and Maryland.

Only a small portion of the commercial crimson-clover seed used in the United States is grown in this country. Most of it is imported from Europe.

The seeds of the weeds most common or troublesome in crimson-clover seed fields are mentioned and illustrated in this bulletin.

This bulletin is a revision of and supersedes Farmers' Bulletin No. 646.

Washington, D. C. Issued August, 1924

CRIMSON CLOVER: SEED PRODUCTION.[1]

By J. M. Westgate,[2]

Formerly *Agronomist in Charge of Clover Investigations, Office of Forage-Crop Investigations, Bureau of Plant Industry.*

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INTRODUCTION.

One of the handicaps to the wider utilization of crimson clover is the fact that it is a winter annual and must be reseeded each year late in the summer. The purchase of the necessary seed on the local market has usually called for an outlay of money at a time when money, and even credit, is particularly scarce on the ordinary farm. The recent development of crimson-clover seed strippers to gather seed for reseeding local areas makes practicable a much wider utilization of this crop than heretofore. A greater acreage of crimson clover will undoubtedly be sown when the seed is produced locally on each individual farm at a small outlay of time and money. Up to the present time the lack of a simple means of harvesting the seed for home use has greatly retarded the seed production and consequently the extension of this soil-improving crop. Fortunately for the grower of crimson clover on the ordinary farm, there has been developed recently a simple type of seed-gathering device which will make it practicable for every farmer to let a part of his crimson clover stand for seed, gather it in the hull, and immediately bag and house it for sowing later in the season. This device is described and illustrated in the following pages. In addition, a brief discussion is given of the requirements necessary for successful seed production, as well as of the methods used for producing seed in commercial quantities for the market.[3]

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[1] This bulletin is adapted primarily to the crimson-clover section, viz, the eastern portion of the United States south of Pennsylvania.

[2] Revised by A. J. Pieters, Agronomist in Charge of Clover Investigations, Office of Forage-Crop Investigations.

[3] The really remarkable soil improvement resulting from the growing of crimson clover in the Southern and Eastern States, where the winters are not too severe, makes it highly desirable that as large an area as possible be seeded to this or a similar leguminous crop. Its value as a soil improver and as a hay crop, the fact that it makes its growth during the fall and early spring, when the land is not occupied by the ordinary money crops, and its presence in a green condition during the winter, thus preventing erosion of the field, all combine to make it a very valuable asset to the farmer who would maintain the productivity of his farm. North of the Cotton Belt it is possible to produce a crop such as corn each season and at the same time make a seeding of crimson clover in the standing corn at the last cultivation, then plowing it under for the succeeding corn crop the following spring. In the Cotton Belt the clover may be seeded from October 1 to November 1. This enables one to produce a leguminous crop as well as one of the ordinary money crops on the land each season. In this connection, see Farmers' Bulletin 1142 for directions as to the growing of the crop and Farmers' Bulletin 579, concerning the utilization of the crimson-clover crop. These bulletins may be obtained free upon application to the Secretary of Agriculture.

SEED PRODUCTION FOR LOCAL USE.

If the crimson-clover seed is to be sown in the immediate neighborhood, it is practicable to sow the seed in the hull with greater prospects of a successful stand than when the cleaned and hulled seed purchased in the market is used. The fact that a bushel of seed in the hull, even when well packed down, ordinarily contains somewhat less than 2 pounds of cleaned seed makes it impracticable to transport the seed long distances on account of its bulk.

There are a number of methods of gathering the seed for local use, the practicability of any particular one being ordinarily dependent upon the quantity of seed to be harvested on a given farm. Where the quantity to be gathered is limited and hand labor is cheap, the seed may be stripped by hand and bagged as gathered. This method, while tedious, is occasionally resorted to where there are no better means available.

Another primitive method of saving the seed is by flailing. After the clover is bunched in the field, a canvas is laid alongside the shock and the seed is flailed out on this to avoid loss. This canvas is dragged from bunch to bunch as the flailing process continues. If barn or shed room is available, the mown plants can be placed under cover shortly after being cut and the seed flailed out later in the season without danger from rain.

The experience of a few individuals indicates that in Virginia and northward to southern Pennsylvania a strip of plants may be left standing along each row of trees, where it is desired to reseed an orchard to crimson clover. In midsummer the cross harrowing will scatter the seed from the unplowed strip and will usually result in a fair seeding. This method is not recommended for the Southern States and is only suggested for experimental trial northward.

HOMEMADE COMB STRIPPERS FOR HARVESTING CRIMSON-CLOVER SEED.

The devices here described can be made during the period of the year when work is slack, and the necessary material can usually be obtained locally at a very small cost. Inasmuch as a device of this kind can be used for only about two weeks in the year, it is important that the cost be as small as possible, and for this reason the machine should be no larger than is necessary for the particular work in hand. It is possible for a single stripper to be utilized by a number of farmers, who may jointly own the device or who may make arrangements with the owner for its use. The clover heads, to strip well with any of these devices, should be thoroughly mature. The heads should also be quite dry, so that no serious heating will occur.

If the clover fields are on ground so stumpy or rough as to make a horse-hauled machine impractical, a hand clover-seed stripper can be readily constructed at a cost of a dollar or two for material and labor. (Fig. 1.) It will be noted that this device consists of a series of fingers or teeth about 10 inches long at the bottom of the box which is to hold the stripped seed. The handle and box are sufficiently heavy to enable the stripper to be swung through a mass of ripe clover plants with enough momentum to strip the seed from the heads without interrupting the swinging motion of the stripper. This device is especially recommended on rocky places or on corn-stubble ground, where a horse-drawn machine would have difficulty in working on account of the corn stubble and other obstacles. The operation of this model is slow and ordinarily is not to be recommended.

For seedings of from 5 to 20 acres, a stripper 3 to 3½ feet wide but with longer teeth is suggested. This is not so wide but that it can be swung on the axle between the wheels taken from an old buggy, between the hind wheels of a carriage or buggy, or even attached to the rear axle of a light farm wagon (figs. 2 and 3). This comparatively narrow machine is recommended where the different fields upon which it is to be used are not connected by wide roads. It can be taken readily on its own wheels along any ordinary wagon road, although if stumps or other obstructions are likely to be encountered it is best to place the stripper box on top of the shafts and axle. If necessary, one man and a horse can operate the machine to good advantage, although a boy to drive the horse and assist in bagging the seed and cleaning the teeth when they become clogged will ordinarily be advisable. With one of these machines seed can be gathered from 1 or 2 acres a day. The seed so obtained will ordinarily be sufficient to seed 8 to 10 acres.

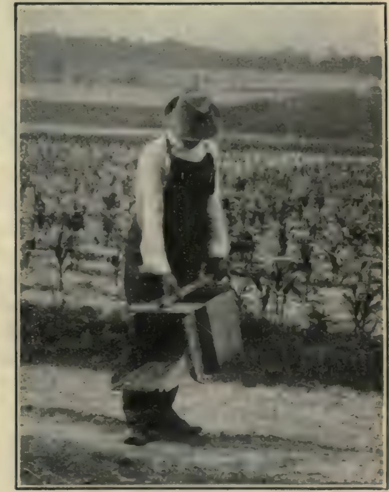


FIG. 1.—A hand-operated comb stripper which has been successfully used in Virginia.

It is also possible to attach a box of this width to the modified cutter bar of an old mowing machine. (Fig. 4.) In this case it is necessary to provide a device for raising and lowering the teeth without dismounting from the mower seat.

Where seed is desired for sowing 20 acres or more, the expense of a machine from 8 to 10 feet in width will ordinarily be justified, especially if the ground is level and free from obstructions. The wide stripper box can be suspended from the axle of an old hayrake or be placed above a low axle of its own with substantial wheels, which may, if necessary, be made entirely of wood. (Figs. 5 and 6.) In transporting this machine from field to field it is ordinarily best to load it on a wagon or hayrack.

The teeth in all the above-described machines are similar. These teeth should be 1¼ inches wide, with the openings between them one-fourth inch wide at the top and three-fourths inch wide below. If the openings between the teeth are somewhat wider at their bases, or toward the rear, than at the points, it will reduce their tendency to choke and will also facilitate cleaning when they become clogged. The teeth should ordinarily be sawed from well-seasoned heart-pine planks an inch or more in thickness. These planks may be of any available width, enough of them being laid side by side to bring the stripper up to the desired width. (Fig. 7.)

It is necessary to have the stripper balanced on its axle, so that it will swing easily. Some sort of a handle at the rear of the stripper is necessary to enable the operator to vary the height of the teeth to accommodate them to the ever-changing height of the clover or to avoid any obstructions which might prove injurious to the machine. Most of the choking is due to weeds which will not slip through between the teeth. These comb strippers, while possessing the advantage of being very cheap and easily constructed, are open to the objection of choking rather easily, especially if the fields are weedy. At the end of the seed-gathering season the stripper should be put under cover, and, to prevent warping, the teeth should be securely fastened between two 6-inch boards.

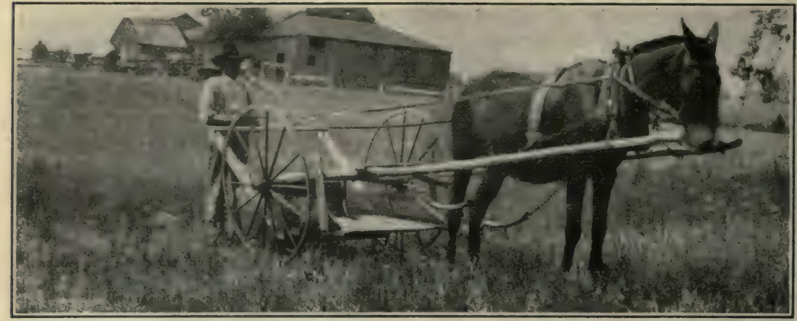


FIG. 2.—A 3-foot comb stripper attached to an old pair of buggy wheels. This type has been used to a considerable extent in the vicinity of Chula, Va.

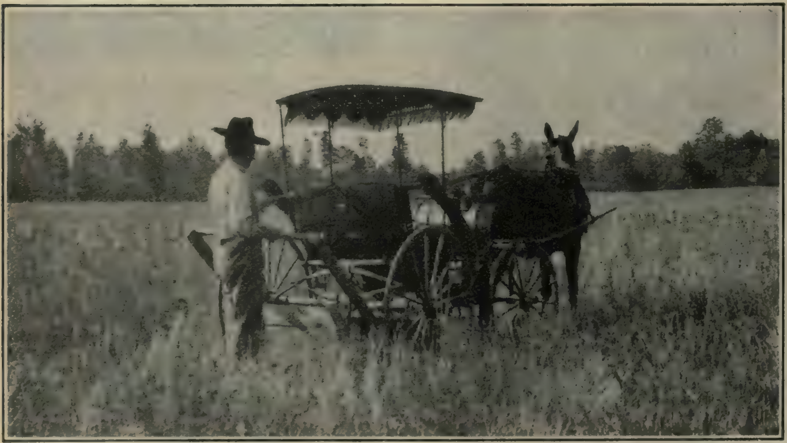


FIG. 3.—A 3-foot comb stripper hung on the rear axle of a buggy.

In some cases enterprising growers have made suction harvesters. These have been put together by using parts of old machinery, including a gasoline engine, so as to create suction, by means of which the ripe pods are drawn from the heads and carried back into a container at the rear. These machines are said to do good work but would probably be too expensive to be specially manufactured unless the crimson-clover industry were to be greatly extended.

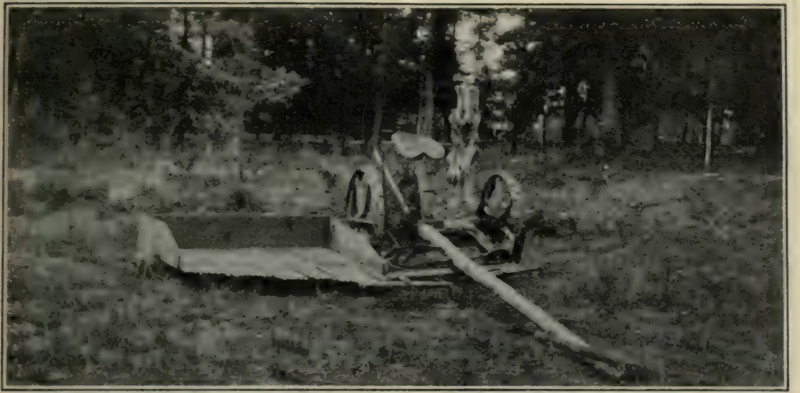


FIG. 4.—A 4½-foot comb stripper attached to an old mowing machine.

While the harvesting of seed in the hull is subject to a few handicaps, such as bulkiness and a tendency to stick together in small bunches when being seeded, yet there are not the serious disadvantages which are often present in the commercial seed-producing areas, where the crop is cut and left in the field until a huller can be obtained. As soon as the stripped seed is harvested it is put in bags,

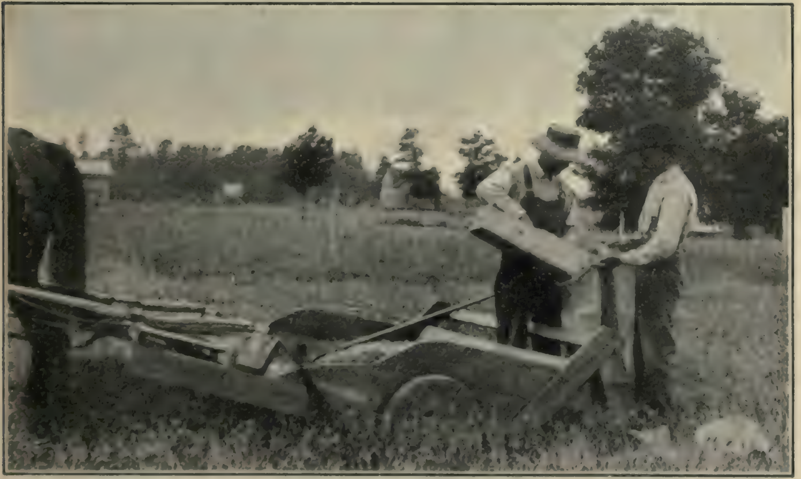


FIG. 5.—Bagging the newly stripped seed from an 8-foot comb stripper at Chula, Va.

which are ordinarily stored in a tobacco barn or elsewhere under cover until seeding time. The bags should be watched, however, and if they show any signs of heating they should be emptied on a covered floor, or at least under a shed, where the piles can be stirred occasionally. Before seeding time comes it is desirable that a sample of 100 hulls be counted out from different portions of the pile and these rubbed out in the palm of the hand. One-half the hulls should show good seeds. If they show more or less than this, due allowance should be made in the rate of seeding. From 75 to 90 good seeds per

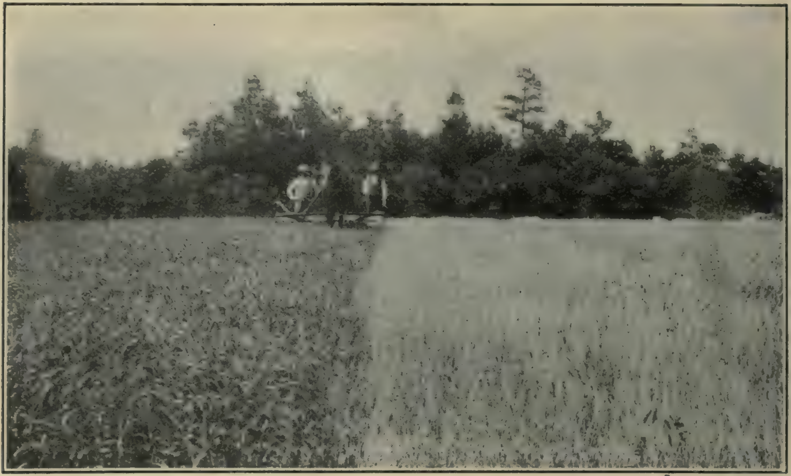


FIG. 6.—An 8-foot comb stripper in operation. Note the cleanness of the work done.

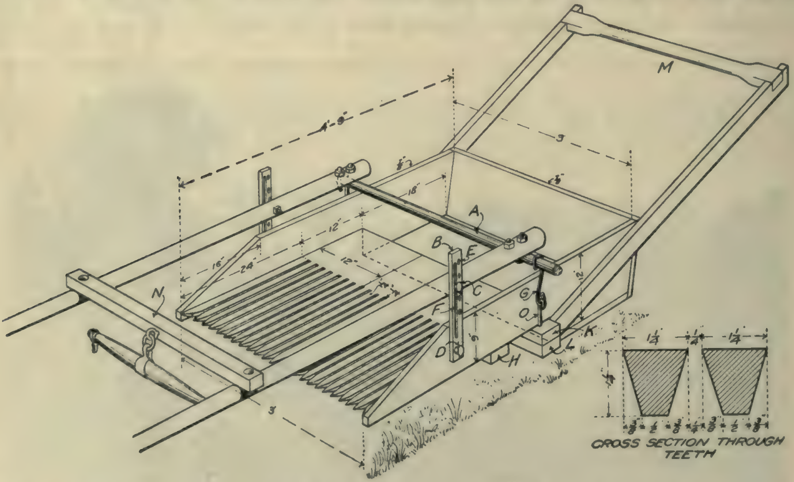


FIG. 7.—Working drawing of a crimson-clover seed stripper. This stripper is designed to be hung on the axle (*A*) between two wheels, which, however, are not shown in the drawing. The iron hooks (*G*) are used for attaching the stripper to the axle. The hooks (*G*) should be of such length as to keep the bottom of the stripper 6 inches above the surface of the ground. The handle (*M*) permits the teeth to be raised or lowered to catch the heads at the proper height. The limits to which the teeth may be raised or lowered are fixed by means of the slot (*F*). This prevents either the front or back of the machine tilting enough to strike the ground. When it is desired to hold the stripper rigid, the removable bolt (*C*) can be taken out and inserted in one of the holes (*E*). The bolt (*D*) should fit loosely in the bottom of board (*B*) to permit the easy action of the attachment. It is necessary to have the scantling (*N*) to which the whiffletree is attached fastened to the shafts far enough in front of the teeth to prevent the horse's hoofs from coming in contact with the teeth of the stripper. The teeth are sawed out of heart-pine boards, which in turn are nailed to scantlings (*H* and *K*).

square foot should be sown to insure a satisfactory stand. A bushel of hulls well packed down will ordinarily make from 1½ to 3 pounds of seed. From 10 to 12 bushels of well-packed seed in the hull are usually sown per acre. Seed of crimson clover more than 2 years old is very apt to fail to produce a stand. Old seed is ordinarily of a brown color.

COMMERCIAL GROWING OF CRIMSON-CLOVER SEED.

The principal drawback in the harvesting of crimson-clover seed for commercial purposes is the tendency on the part of the plants to shatter their seeds almost as soon as they are ripe. For this reason it is necessary to cut the field a little before it has reached the proper stage for harvesting by strippers. It is also desirable that the plants be somewhat damp, as with dew, when cut, in order to retard this shattering of the seed. Any mechanical device or method of harvesting which will reduce the shattering while being harvested is to be strongly recommended. In some sections it is the practice to cut during the night, in order to avoid shattering the seed. In doing this it is necessary to hang a lantern on the end of the tongue of the mower or reaper. If a mowing machine only is available, it is sometimes the practice to attach a sheet or canvas to the cutter bar, the two rear corners of which are held up by a man walking behind. The cutter bar is set high enough to cut the stems just below the heads. The resulting piles of heads are placed under cover or hauled direct to the huller. The stands are usually cut for seed about a week or 10 days after the last blossoms have faded and when the last maturing seeds in the top of the head have reached the soft-dough stage. The ordinary procedure in the seed-producing sections is to use a self-rake reaper (fig. 8), which deposits the newly cut stems with the heads all turned one way in small gavels at the side of the reaper, so that the horses do not trample them on the succeeding round. These gavels are sometimes placed two or three together in a small bunch to cure, but quite often they are left as dropped until the huller comes, when they are loaded one at a time on tight-bottomed hayracks and hauled to the huller.

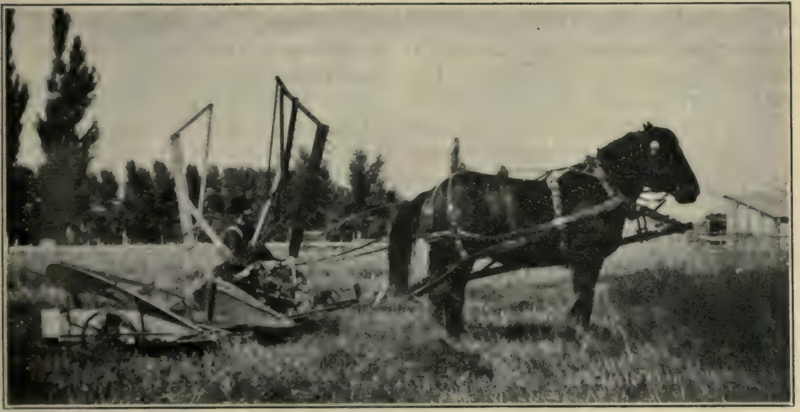


FIG. 8.—Self-rake reaper for dropping the newly cut plants in bunches.

The seed is generally hulled with a special huller, which is equipped with two cylinders, one to shatter the hulls off the heads and the other to rub the hulls from the seed. The cleaners, which are attached to the hullers, deliver the seed in a fairly good marketable condition, although it is usually the custom to run the seed through a small cleaning machine before it is put on the market. The threshed clover straw may be scattered back on the ground and turned under for soil-improving purposes or it may be used for bedding.

HOW TO GROW A GOOD CROP OF SEED.

It has been found that the first few seedings of crimson clover on an ordinary field generally result in better crops of seed than are made after the clover has been grown upon a particular field for a considerable number of years. It is a well-known fact that too much nitrogen in the soil induces an overgrowth of stems and leaves at the expense of the seed crop. This is probably what happens to the crimson-clover field when the stubble or entire crop is turned under during successive seasons, thus making the soil presumably somewhat too rich in nitrogen fertilizer for the best results in seed production. For this reason any of the richer and more fertile soils will also be found to have a tendency to produce stems and leaves at the expense of the seed, even on fields where no crimson clover has recently been grown. This condition is desirable if hay or green manure is the main object, but if large seed crops are wanted soils of medium fertility or those which have not grown crimson clover successfully for more than two or three years should be chosen for the prospective seed crop. On ground of comparatively low fertility the first or even second crop of crimson clover may not be able to make a growth vigorous enough to produce even a crop of seed. If the ground is rather infertile, it should receive potash and phosphoric acid in the form of commercial fertilizers. For a good seed crop the stand must not be too thick, but it should be thick enough to keep down the weeds. In view of the difficulty of separating weed seeds from crimson-clover seed, it is important that the field be free from weeds that mature their seed about the same time as crimson clover.

SEED-PRODUCTION CENTERS IN THE UNITED STATES.

Until recent years domestic crimson-clover seed for the trade was largely produced in Delaware and in eastern Maryland, but production in these sections has fallen off very considerably. The high price of hay, smaller seed yields, and competition with imported seed have tended to draw farmers away from the business of seed production. In 1916 considerable interest developed in this industry in Franklin County, Tenn., in which and in the adjacent counties the bulk of the commercial crimson-clover seed harvested in the United States is produced at present. The yields in this section vary from 4 to 6 bushels an acre on the better soils to 10 or 11 bushels on the poorer hilltops.

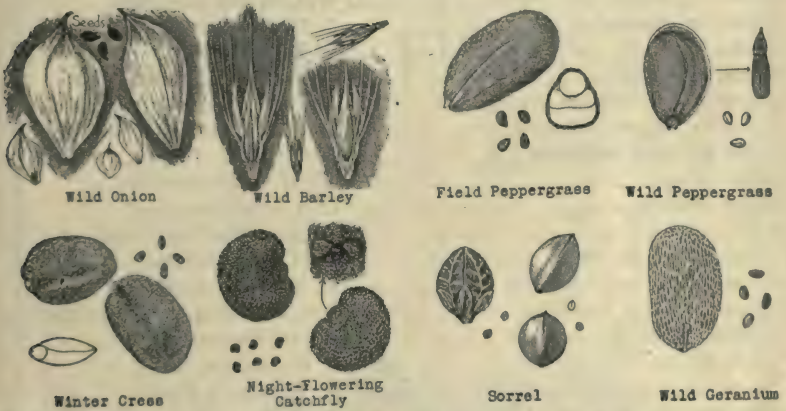
Unhulled seed for local use is harvested in many places from Delaware to Georgia, but especially in parts of the Piedmont section of Virginia and South Carolina.

Much of the uncertainty of the crimson-clover seed crop lies in the frequent occurrence of a rainy spell after the crop is cut and before a huller can be secured to thresh the seed. An untimely rain will often materially injure the seed and sometimes cause it to germinate. When the seed can be stripped and bagged for local use, it can readily be housed and injury from rain thus avoided.

The commercial production of crimson-clover seed in this country is especially handicapped by frequent untimely rains which occur after the crop is cut and before the services of a huller can be obtained. A considerable acreage in a given locality is required to justify the presence of a huller in that vicinity. Where it is not desired to raise seed for commercial purposes, simple devices, some types of which can be made on the farm from readily available material at the expenditure of a few dollars, make it possible for anyone with a crimson-clover field to obtain seed for reseeding purposes.

TROUBLESOME WEEDS IN CRIMSON-CLOVER FIELDS.

The most dangerous weeds (fig. 9) in a crimson-clover seed field are those which mature at the same time as the clover. Some of these weeds are so nearly the size and weight of crimson-clover seed that they can not be separated in cleaning, while others, such as wild barley, are particularly troublesome when the unhulled seed is used. Below are listed the worst weeds found in crimson-clover seed fields. Besides these the immature seeds of oats, wheat, and rye sometimes make trouble, as the shriveled seeds can not be wholly cleaned out and their presence injures the sample. Winter turnips and rape when previously grown in the field may also persist, and the seed can not be readily separated from that of crimson clover.



Wild Onion Wild Barley Field Peppergrass Wild Peppergrass

Winter Cress Night-Flowering Catchfly Sorrel Wild Geranium

FIG. 9.—Seeds of weeds which often infest crimson-clover fields. These should be avoided when purchasing seed.

1. Wild onion (*Allium vineale*). The bulblets gum the rasps of the hulling cylinder. (Fig. 9.)

2. Field peppergrass (*Lepidium campestre*). A heavy seeder, and it is almost impossible to separate its seed from that of crimson clover. (Fig. 9.)

3. Winter cress (*Barbarea praecox*). Abundant and difficult to separate. (Fig. 9.)

4. Sorrel (*Rumex acetosella*). An abundant seeder, although the seeds can be separated. (Fig. 9.)

5. Wild geranium (*Geranium* sp.). An abundant seeder, although the seeds can be separated. (Fig. 9.)

6. Wild barley (*Hordeum pusillum*). The worst weed in unhulled seed. Impossible to separate; therefore it becomes worse as the use of unhulled seed continues. (Fig. 9.)

7. Night-flowering catchfly (*Silene noctiflora*). Bad locally. (Fig. 9.)

8. Wild peppergrass (*Lepidium virginicum*). Abundant in Tennessee. Seed is easily cleaned out. (Fig. 9.)

9. Evening primrose (*Oenothera* sp.). An abundant seeder, although the seeds can be separated.

10. Buttercup (*Ranunculus* sp.). Not common, but difficult to separate.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

January 24, 1924.

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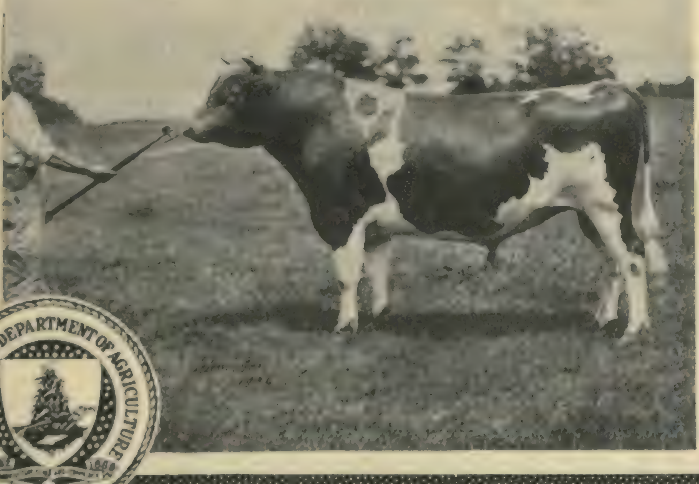
Ind

U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1412

CARE AND MANAGEMENT OF DAIRY BULLS



1862 1889

GOOD DAIRY BULLS are worth so much for building up the production of dairy herds that they should be properly taken care of.

Because of their temperament, dairy bulls are often difficult to handle; consequently they do not always receive proper care, exercise, and management.

Many bulls, because they are not properly managed, fail to give best results as herd sires.

This bulletin tells briefly how to handle dairy bulls safely, and how to keep them in good condition, and also discusses numerous problems bearing on their care and management.

Washington, D. C. Issued June, 1924

CARE AND MANAGEMENT OF DAIRY BULLS.

By J. R. DAWSON, *Associate Dairy Husbandman, Dairy Division, Bureau of Animal Industry.*

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IMPORTANCE OF PROPER CARE.

GOOD SIRES are absolutely necessary to dairymen, as it is largely through the use of good sires that high-producing herds are built up.

Because of the nervous temperament and great strength of mature bulls, they need to be handled with care. Many valuable bulls are prematurely lost for service because of poor care and poor management.

Newspapers and farm papers frequently tell of persons being injured, or killed, by bulls, as a result of improper equipment or wrong handling. Because of such occurrences, dairy bulls have come to be looked on in some cases as necessary evils. This attitude often means neglect in such essentials as feeding, exercise, removal of manure from pens, and various other details of care.

According to the last census, the total number of dairy bulls 1 year old or older, in the United States, was 772,320, about one farm in every six having dairy cattle kept a bull. Some of these were good bulls, while many of them were not. One of the most important objects of the dairyman should be to have the services of a well-bred bull. Then, having a good bull, he should be given the care and management that will insure the greatest profit from him.

FEEDING.

Bull calves to be raised for breeding purposes should be fed and handled much the same as heifers.[1] If skim milk is fed, it is desirable to give the bull calves, after they are 3 months of age, a little more grain than the heifers get, and to delay weaning to 8 or 10 months. As a rule, bulls grow somewhat faster than heifers, and this feeding enables them to attain their best size and development. Undersized bulls are seldom looked upon with favor.

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[1] See Farmers' Bulletin 1336, Feeding and Management of Dairy Calves and Young Dairy Stock.

A bull that has an inheritance for large size, but is small because of improper development resulting from poor feeding, does not transmit small size to his progeny. It is difficult, however, for one unfamiliar with the ancestry of the bull to determine whether his small size is due to heredity or to poor development.

Bulls should be of sufficient size and maturity for light service at 10 or 12 months of age. From this time on, the grain may be much the same as that given the cows in milk. Some breeders feed their regular herd mixture. Bulls should be fed enough to keep them in a vigorous physical condition, but not too fat, because high finish has a tendency to make them sluggish. This is especially true of old bulls, which often have a tendency to become weak on their legs, owing to excessive weight. In this condition, they hesitate to mount and therefore are slow breeders. Golden Glow's Chief, 61460, the great Jersey sire, retained his vigor until his death at 15 or 16 years of age. He became so weakened in his hind legs, however, due to his excessive weight, during the last two or three years of his life, that he was unable to mount cows. If bulls become too fat, cut down the grain ration, and give regular exercise.

The amount of grain to feed daily varies from 4 to 10 pounds, depending on the size and condition of the animal and the kind of roughage. The following grain mixtures have been used with success:

Mixture No. 1.	Pounds.	Mixture No. 2.	Pounds.
Ground corn	300	Ground oats	300
Ground oats	200	Wheat bran	200
Wheat bran	200	Ground corn or barley	100
Linseed meal	100	Linseed meal	100

Ground oats are considered especially valuable for bulls. Cottonseed meal is not usually regarded with favor, especially when fed in large amounts. Some breeders think it causes impotency.

The legume hays—alfalfa, clover, vetches, soy beans, cowpeas—are excellent roughages, and should be fed liberally if possible. They are high in protein and mineral matter, especially alfalfa, and are valuable for keeping heavily used bulls in condition. Bulls should be fed 10 to 20 pounds of these legume hays a day, depending on their size and condition. If nonleguminous roughages are fed—timothy hay, prairie hay, corn silage, fodder, or stover—feed a grain mixture higher in protein.

On some farms the bulls are given the spoiled or musty hay, or waste feed, left by other animals. This is poor practice. It is just as necessary to feed the bulls properly as it is the cows.

Breeders differ as to the advisability of feeding silage. Some maintain that a considerable amount of silage is likely to lessen the vigor of a bull, and may make him sterile. Others feed silage in large quantities and report no undesirable results. So far as experimental work shows, it is probable that silage does not have any direct effect on the breeding powers. Large amounts of silage, or other extremely bulky feeds, may have a tendency to distend the paunch so that the bull becomes too heavy on his feet. From 10 to 15 pounds of silage a day, with other roughage, can be fed safely without impairing the usefulness of the animal.

Dairy bulls should have plenty of water. This matter is often neglected, especially when there is not a constant supply in the stall or pen and when the bull is difficult to handle. A bull should be watered at least once a day during the winter, and twice a day during the summer.

Occasionally the question is asked whether the feed has an influence on the number or activity of the sperm cells of a bull. If there is any effect, it is probably indirect, and depends on the physical condition of the bull rather than directly on the feed.

HOUSING AND EXERCISE.

If bulls are to be profitable they must be properly housed, and they must get exercise. It is poor practice to compel a bull to stand in a small stall constantly without exercise; it may ruin him as a breeder, and make him vicious.

The main things to be considered in providing quarters for bulls are: (1) Safety and ease in handling; (2) comfortable stable or shed for protection from weather; (3) provision for exercise.

STABLING.

A shed or barn opening into a paddock or yard is a practical shelter for a bull. The shed may be left open on the south side to make it light and dry, but closed on the other sides to keep out cold winds and storms. A certain amount of outdoor life is beneficial, although a bull does not appear to best advantage when kept in the open, because of the heavy coat of hair he puts on in cold weather. In a cold climate, or extremely cold seasons, it is well to have a closed barn. The barn should be well ventilated and well lighted. Either a shed or a barn should be large enough to allow the animal to move around freely. A strong stanchion or tie, and a feed manger are advisable. A feeding alley in front is a good feature, so that the handler will not have to enter the pen to feed. If the shed opens into a yard, make a gate for the opening. By driving the animal into the pen and closing the gate, a man can work in the shed without danger from the bull.

The tie, or stanchion, may be made of heavy planks, or iron. With the bull in the stanchion, one can work in the pen with little risk. Often a rope is run from the feed alley through a pulley and attached to the stanchion. By placing feed in the manger, the bull will put his head through the stanchion, and the stanchion can then be shut with the rope.

Some breeders have a box stall in the main barn, with a door opening into a yard. The advantages of this plan are that the bull can see the other cattle and can be fed and cared for with the rest of the herd. The box stall should be built strong, preferably of iron pipes set in concrete. It is a good idea to have stanchion, manger, and water supply in the stall. Take particular care to see that the catches and locks on doors and gates are such that the bull can not open them with his head or horns.

SAFE-KEEPER BULL PEN.

A pen known as the "safe-keeper" bull pen has been designed by the United States Department of Agriculture, primarily for handling unruly and vicious bulls. (Fig. 1.) This pen includes a shed with stanchion and manger, the latter being reached from a feeding alley in front. A sliding door, opening into a yard, is operated with ropes from the feeding alley, so that the bull can be shut in the adjoining yard while the stable is being cleaned. A gate and a breeding rack are so placed in the yard that it is unnecessary to go into the yard where the bull is. The pen may be in a detached building, or in a corner of the barn. Breeders have used various modifications of this plan with success and have kept many valuable sires that otherwise would have had to be disposed of.[2]

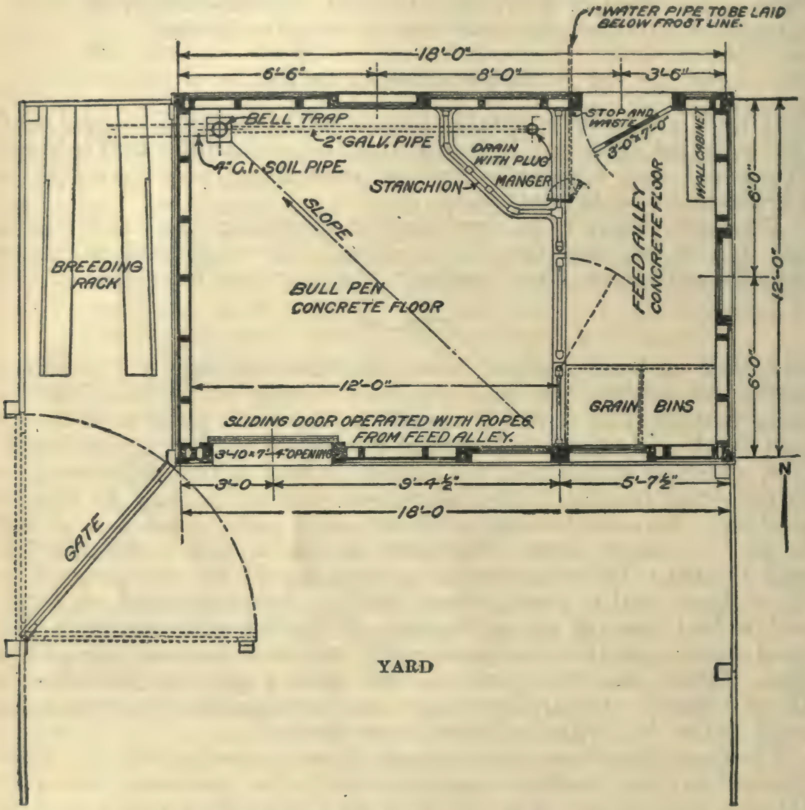

FIG. 1.—Plan of "safe-keeper" bull pen.

Bulls should have a clean, well-drained yard or paddock for exercise, in connection with the barn or pen. Experience shows that exercise plays an important part in keeping a bull vigorous and healthy.

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[2] Plans and specifications of the safe-keeper bull pen will be sent free of charge by the Dairy Division, United States Department of Agriculture, Washington, D. C., on request.

FENCING.

Under no condition should a bull be placed in a yard or pasture that does not have a substantial fence. After a bull has once broken through a fence, it is much harder to keep him in. The fence should be 5 to 6 feet high or too high for him to jump over. Solid fences—those that obstruct his view—are not advisable, except possibly with extremely vicious bulls. Bulls usually are more contented if they can see beyond the fence. If the fence is solid, it is a good plan to make a mound of earth near the center of the inclosure high enough so the bull can see what is going on outside. This method keeps him away from the fence, and he is not so anxious to get out.

The fencing materials most commonly used are woven wire, barbed wire, planks, rails, and iron pipe. If barbed wire is used put the posts not more than 8 to 10 feet apart, stretch the wire tight, and space the strands 8 to 12 inches apart. Five-foot heavy woven-wire fencing, with one or two strands of barbed wire on top, makes a good, durable fence.

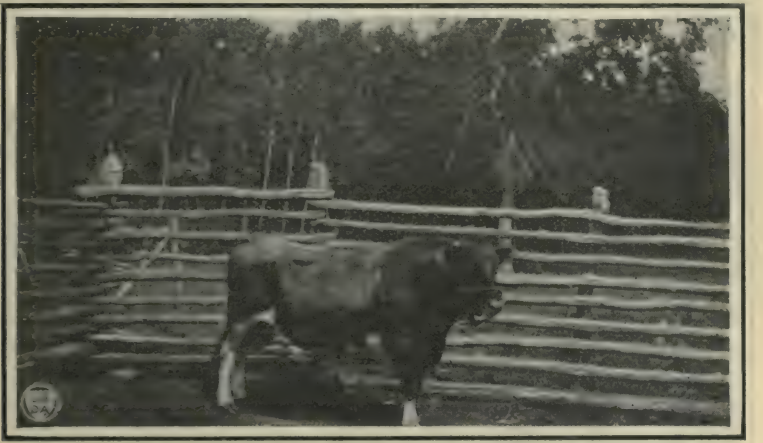

Fig. 2.—A cheap and practical pole fence. The poles were cut in the timber beyond.

A pole or rail fence is practical and cheap on farms where a man has the material to use.

Set wooden posts 8 feet apart, preferably in concrete. Cut the poles to right length, with enough room at each end to nail to the posts. Chop a flat place at each end of the poles so they can be nailed solidly against the posts. (See fig. 2.) Space the lines of poles 8 to 12 inches apart. Important: Nail poles to posts from what will be the inside of the pen, to prevent the bull's forcing the nails out by pushing against the poles. If poles or rails are not available, 2 by 6 inch planks may be used. (See fig. 3.)

Another type of fence often used consists of reinforced-concrete posts set 8 to 10 feet apart, with iron pipe for rails. (See fig. 6.) The rails are run through holes in the posts. If concrete posts are used, they must be strongly reinforced. While this type of fence may be expensive, it is strong and substantial and will last a long time.

Danger and inconvenience will be avoided if all gates are strong, and equipped with reliable locks and catches.

MEANS OF EXERCISE.

The importance of exercise is often underestimated. Many bulls, after their value has been proved, are found to be sterile or slow breeders, due largely to close confinement and lack of activity.

The pen should be large enough to permit the bull to take plenty of exercise. But many bulls, even when they have a roomy yard, are inclined to be lazy and sluggish and do not stir about enough. As regular exercise helps materially to keep bulls in vigorous condition, it may be necessary to force the sluggish bull to take exercise, and various methods have been devised for the purpose.

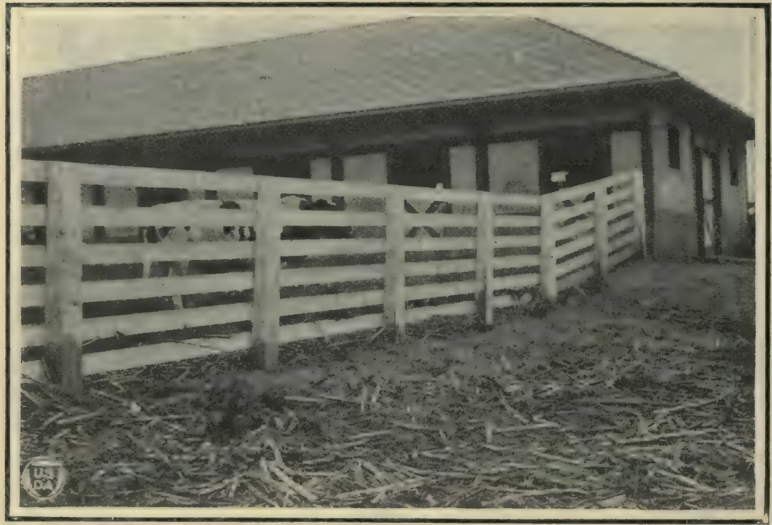

FIG. 3.—Fence of 2 by 6 inch planks on heavy posts.

One way to make bulls take exercise is to yoke them up and work them like oxen. Where there is only one bull, he can be hitched and worked with a horse. Bulls can be used to haul manure, plow, pull stumps, and do various other jobs. Thus the bull not only gets exercise, but at the same time does some farm work. (See fig. 4.)

The treadmill is used in some cases (fig. 5), but is not always satisfactory, because the bull sometimes refuses to walk on the tread unless he is watched, and he may also learn various tricks to stop the mill. Then, too, if the incline is wet or slippery, the animal may fall and suffer injury.

In an experiment at the Washington State Agricultural College, on the use of the treadmill,[3] it was found that this sort of exercise, in the case of a slow-breeding bull, shortened the time required for service. Also, the activity and length of life of the spermatozoa were increased.

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[3] Washington Agricultural Experiment Station, Bulletin No. 158.

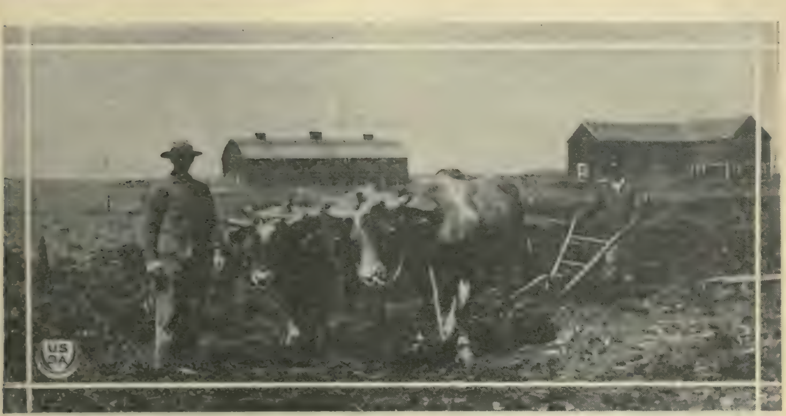

FIG. 4.—Two bulls hitched to plow to exercise them.

If two or more bulls are kept, they may be turned out together. This usually results in their getting considerable exercise, but they may injure one another, especially if they have horns. There are cases on record of valuable sires being injured to such an extent as to make them useless as breeding animals. If a young bull is turned in with an older one, he probably will be active enough to keep out of the way. Having the pen, or lot, large enough, so it would be hard for one bull to corner the other, lessens the danger of the bulls injuring each other. The owner should use his own judgment as to the merits of this plan. (See fig. 6.)

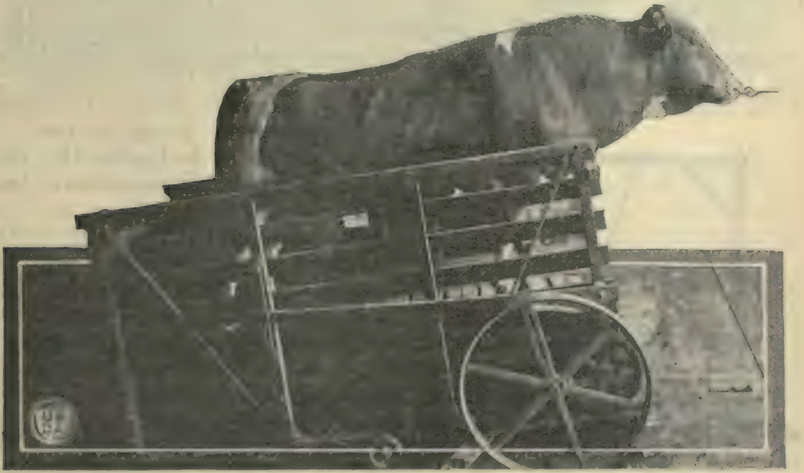

FIG. 5.—Exercising a bull in a treadmill.

Bulls may be induced to exercise themselves with an empty barrel or keg by bunting or rolling it around the pen. The keg may be left on the ground, or be hung by a rope or chain, low enough so the bull can butt it with his head; or, a block of wood, with the corners rounded, will serve the purpose. Some bulls spend hours playing with contrivances of this sort, while others pay little attention to them. (See fig. 7.)

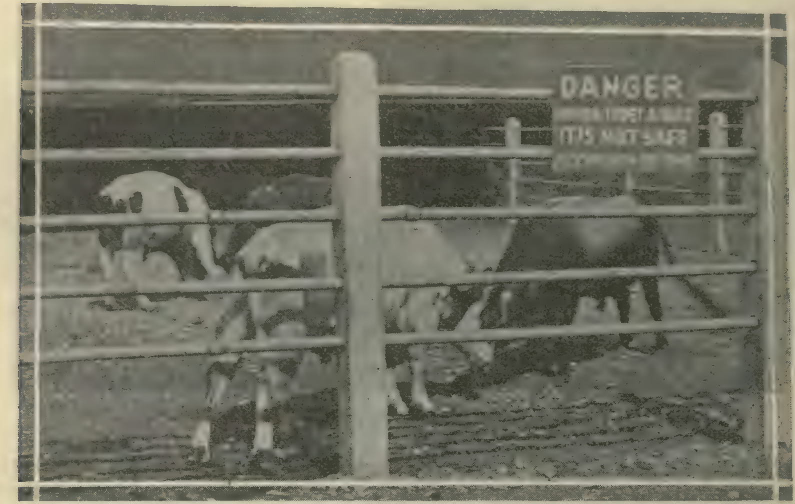

FIG. 6.—Bulls in same pen getting exercise by playing. The owner must use his judgment as to the merits of this plan.

When an exercise pen is not available, it is a common practice to tie the bull to a ring which slides on a suspended wire or cable. (See fig. 8.) The cable should be strong, and 75 to 100 feet long. A five-eighths inch iron ring, with swivel link, is good. The cable should be high enough so the bull can not get his feet over the lead chain. Twelve to fifteen feet of lead chain should be all right.

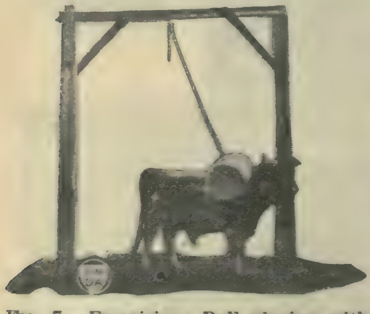

FIG. 7.—Exercising: Bull playing with a suspended block of wood. A strong, empty keg may also be used.

A revolving sweep will give the bull some exercise, if he will use it. These schemes, however, are not always successful, because sometimes when the bull gets used to the devices he will lie down and take but little exercise.

Bulls are sometimes staked out or tied to a weight that can be dragged around from place to place while grazing. If this plan is used, it is well to put the chain around the horns and on down through the ring in his nose. It is a good plan to wrap the chain with tape or cloth, or inclose it in a short piece of garden hose, so as not to rub off the hair and skin.

If there is no other method of exercise suitable, the bull can be led around a few minutes a day, but this takes considerable time and there is an element of danger.

SERVICE.

Bull calves should be separated from the heifers before they are 6 months old, as they may begin then to get heifers in calf.

Bulls are old enough for light service at 10 or 12 months of age, but until they are 18 months old they should be bred to only a few cows. The bull should not serve more than four or five cows before he is a year old, but after that the number of services may gradually be increased. At 2 years of age, during the breeding season, he should be able to serve four or five cows a week, without injury. It is not advisable to allow a mature bull to serve more than two cows in one day, nor more than 75 or 80 during the year. Cases are on record in which bulls have sired a considerably larger number of calves in a year's time, but such is not advisable as a general practice, because in most herds the breeding is not evenly distributed throughout the year.

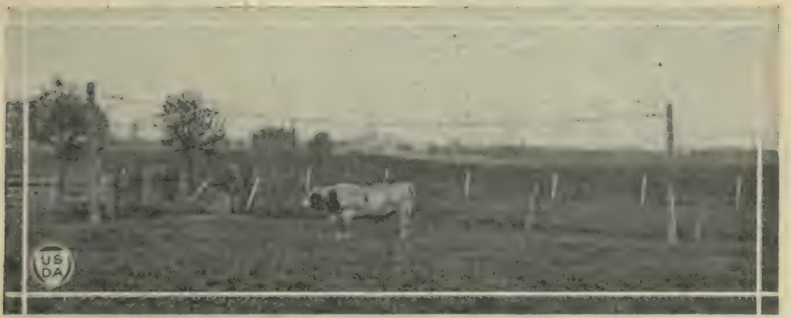

FIG. 8.—Exercising: Bull tied to a suspended cable, which allows considerable exercise.

In breeding cows, one service or leap is usually satisfactory, except possibly in the case of a heifer bred for the first time, when two services may be advisable. Owing to the excessive weight of a heavy bull, the heifers or cows may fall, or it may be difficult to get them to stand. In this event a breeding rack may be helpful.

The breeding rack consists of a stall and a stanchion into which the cow is led for breeding.[4] On each side is an incline with cleats on which the bull rests his feet when he mounts for service. The weight of the bull is on the rack and not on the cow. Some are so constructed that the stanchion can be moved forward or backward, according to the size of the cow being bred. (See fig. 9.)

If a young bull is being bred to a large cow, it is often difficult for him to mount high enough for service. Standing the cow in a shallow pit will materially help him.

In general, the bull should never be allowed to run with the herd. If he does, some heifers will undoubtedly be bred too young. In addition, there is no accurate method of telling whether the cows are safely with calf, and those that have breeding trouble are not quickly discovered. Then, too, there is no record of when to expect calves and prepare the cows for calving. There is also a tendency for the bull to waste his vitality and energy by serving the same cow several times. A bull allowed to run in pasture with the herd usually gets ample exercise, however, which may be important enough to offset the vitality he may waste in serving too often.

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[4] Plans and specifications for a breeding rack will be furnished free of charge by the Dairy Division, United States Department of Agriculture, Washington, D. C., on request.

KEEPING RECORDS.

A breeding record of the bull should be kept. It enables the breeder to know when to expect calves. With purebred animals, it is often necessary to know the exact service date.

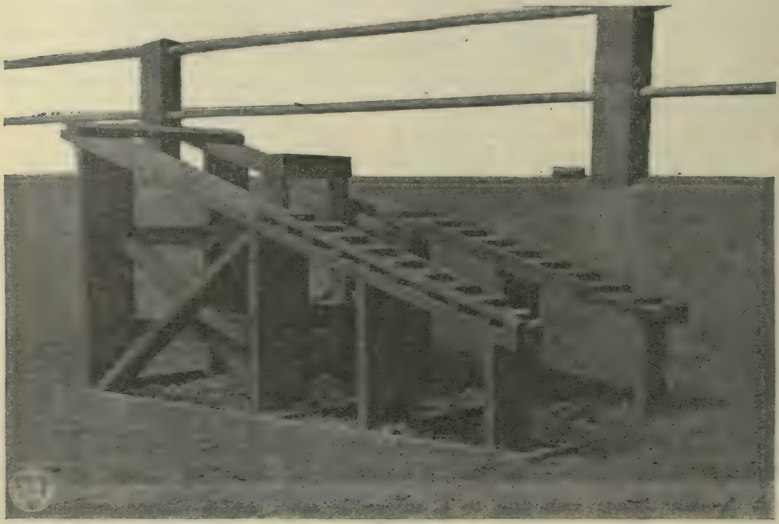

FIG. 9.—Breeding rack.

The system of record keeping need not be elaborate. The following is a satisfactory and practical form:

Name or number of cow.	Date bred.			Date due.	Date calved.	Bull used.	Sex of calf.	Remarks.
	1	2	3					
Roan........	Feb. 17	....	....	Nov. 26	Nov. 28	Prince....	Male......	Sold for veal.
Rose........	Jan. 3	Jan. 24	....	Nov. 2	Nov. 1	...do......	Female...	

These sheets may be made at home with pen and ink, and tacked up near the bull pen for ready reference. The records can be copied into the herdbook for future reference.

A gestation table is of assistance in calculating the time of calving. The average gestation period is 283 days. If a gestation table is not at hand, a good plan is to count back 3 months from the date of service and add 10 days. Thus, if a cow is bred on February 4, by counting back 3 months and adding 10 days, the calving date will fall about November 14.

TABLE 1.—*Gestation table for cows.*

Served.	Due.	Served.	Due.	Served.	Due.	Served.	Due.	Served.	Due.	Served.	Due.	Served.	Due.	Served.	Due.	Served.	Due.	Served.	Due.	Served.	Due.	Served.	Due.
Jan.	Oct.	Feb.	Nov.	Mar.	Dec.	Apr.	Jan.	May.	Feb.	June.	Mar.	July.	Apr.	Aug.	May.	Sept.	June.	Oct.	July.	Nov.	Aug.	Dec.	Sept.
1	10	1	10	1	8	1	8	1	7	1	10	1	9	1	10	1	10	1	10	1	10	1	9
2	11	2	11	2	9	2	9	2	8	2	11	2	10	2	11	2	11	2	11	2	11	2	10
3	12	3	12	3	10	3	10	3	9	3	12	3	11	3	12	3	12	3	12	3	12	3	11
4	13	4	13	4	11	4	11	4	10	4	13	4	12	4	13	4	13	4	13	4	13	4	12
5	14	5	14	5	12	5	12	5	11	5	14	5	13	5	14	5	14	5	14	5	14	5	13
6	15	6	15	6	13	6	13	6	12	6	15	6	14	6	15	6	15	6	15	6	15	6	14
7	16	7	16	7	14	7	14	7	13	7	16	7	15	7	16	7	16	7	16	7	16	7	15
8	17	8	17	8	15	8	15	8	14	8	17	8	16	8	17	8	17	8	17	8	17	8	16
9	18	9	18	9	16	9	16	9	15	9	18	9	17	9	18	9	18	9	18	9	18	9	17
10	19	10	19	10	17	10	17	10	16	10	19	10	18	10	19	10	19	10	19	10	19	10	18
11	20	11	20	11	18	11	18	11	17	11	20	11	19	11	20	11	20	11	20	11	20	11	19
12	21	12	21	12	19	12	19	12	18	12	21	12	20	12	21	12	21	12	21	12	21	12	20
13	22	13	22	13	20	13	20	13	19	13	22	13	21	13	22	13	22	13	22	13	22	13	21
14	23	14	23	14	21	14	21	14	20	14	23	14	22	14	23	14	23	14	23	14	23	14	22
15	24	15	24	15	22	15	22	15	21	15	24	15	23	15	24	15	24	15	24	15	24	15	23
16	25	16	25	16	23	16	23	16	22	16	25	16	24	16	25	16	25	16	25	16	25	16	24
17	26	17	26	17	24	17	24	17	23	17	26	17	25	17	26	17	26	17	26	17	26	17	25
18	27	18	27	18	25	18	25	18	24	18	27	18	26	18	27	18	27	18	27	18	27	18	26
19	28	19	28	19	26	19	26	19	25	19	28	19	27	19	28	19	28	19	28	19	28	19	27
20	29	20	29	20	27	20	27	20	26	20	29	20	28	20	29	20	29	20	29	20	29	20	28
21	30	21	30	21	28	21	28	21	27	21	30	21	29	21	30	21	30	21	30	21	30	21	29
22	31		Dec.	22	29	22	29	22	28	22	31	22	30	22	31		July.	22	31	22	31	22	30
	Nov.	22	1	23	30	23	30		Mar.		Apr.		May.		June.	22	1		Aug.		Sept.		Oct.
23	1	23	2	24	31	24	31	23	1	23	1	23	1	23	1	23	2	23	1	23	1	23	1
24	2	24	3		Jan.		Feb.	24	2	24	2	24	2	24	2	24	3	24	2	24	2	24	2
25	3	25	4	25	1	25	1	25	3	25	3	25	3	25	3	25	4	25	3	25	3	25	3
26	4	26	5	26	2	26	2	26	4	26	4	26	4	26	4	26	5	26	4	26	4	26	4
27	5	27	6	27	3	27	3	27	5	27	5	27	5	27	5	27	6	27	5	27	5	27	5
28	6	28	7	28	4	28	4	28	6	28	6	28	6	28	6	28	7	28	6	28	6	28	6
29	7	29	8	29	5	29	5	29	7	29	7	29	7	29	7	29	8	29	7	29	7	29	7
30	8			30	6	30	6	30	8	30	8	30	8	30	8	30	9	30	8	30	8	30	8
31	9			31	7			31	9			31	9	31	9			31	9			31	9

COST OF KEEP.

The cost of keeping a bull is an important item to consider. The individual farmer will want to know what the cost will be. The question may also come up in connection with bull associations, or other farms of joint ownership. The following table shows the average feed consumption, and other costs, on 95 bulls in Vermont, Indiana, and western Washington.[5] The figures are for an average of two years:

TABLE 2.—*Cost of keeping a bull for one year.*

	Vermont.	Indiana.	Washington.
Concentrates........pounds..	336	1,399.7	630
Dry roughage........do....	6,734	4,025.4	5,967
Succulent roughage........do....	2,396	6,002.8	3,069
Bedding........do....	269	645.4	43
Pasture........dollars..	[1] 1.92	4.56	13.56
Labor........hours..	37.7	35.7	40.4
Total other costs [2]........dollars..	14.21	29.71	41.81

[1] Acres.

[2] "Total other costs" includes interest, insurance, bull's share of buildings, depreciation, etc.

A number of factors enter into the cost of keeping a bull. Age, method of feeding, and price of feeds are some of them. From Table 2 one can estimate the amounts of the different kinds of feed, and apply the prices of feed, labor, etc., prevailing in the particular locality.

BUYING AND SELLING.

Most dairymen buy young bulls of breeding age, use them for two years, and then, to avoid inbreeding, sell them. This is not good practice, because in a large number of cases the bulls are sold for slaughter, or knowledge of their whereabouts is lost.

It is often found that the daughters of these bulls are greatly superior to their dams, but the sires have been disposed of before the fact becomes known.

It is better to keep the bulls until production records of their daughters can be compared with records of the dams. If the production records of the daughters are superior, and other considerations warrant, such bulls should be kept in the herd or disposed of in such a way that their services are not lost.

Of course, if the production records of the daughters do not justify keeping the bull as a herd sire, he should be disposed of, preferably for beef.

In order to retain ownership, or use, of prepotent bulls, breeders often lease or lend them for definite periods to other breeders. This may be done also with younger, unproved sires. The kind of contract or lease, and the cash consideration, will depend on conditions. It is advisable to include in the contract, or agreement, a clause specifying proper care and feed, number of services, and health precautions. In special cases, it may be advisable to specify that all the bull's daughters be tested for milk and fat production after they freshen.

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[5] United States Department of Agriculture Bulletins Nos. 923, 858, and 919.

In buying a herd bull, one may have a choice of a young animal of breeding age or an older proved or unproved bull. A proved sire must have daughters with production records that can be compared with similar records of their dams. The records of the daughters may be better than those of their dams, or they may not be so good. In general, bulls that have proved to be superior in this respect are comparatively scarce, and when they are available usually command a high price. Then, too, many of these sires are rather old, and may be uncertain breeders, or they may be dangerous to handle. For these reasons many breeders feel that they are justified in buying young, unproved bulls of good type from high-producing ancestry. This certainly is the best practice to follow, if satisfactory proved sires can not be obtained. If care is exercised in their selection, one can usually expect beneficial results from young sires.

It is good practice to inspect bulls before buying. This often saves disappointment, and gives one a knowledge of the conditions under which the animals were raised. In addition, one can usually see the type of the sire and dam, which are important points in selecting bulls. Many satisfactory sales are made by mail, and reputable breeders have built up a considerable business on this plan. Photographs are valuable, but often misleading.

If bulls are shipped a great distance, they usually do not appear to best advantage when received. For this reason, judgment should be withheld until they have had opportunity to recover from the trip. It is a good plan to keep them isolated or away from the herd for some time. Many are purchased subject to a 60 or 90 day retest for tuberculosis, which is a wise precaution. In this case, the matter of isolation is usually specified in the agreement between buyer and seller.

Some dairymen find it difficult to sell their bulls at a profit, while others find it the best-paying part of their business. As a general thing, purebred bulls backed up with high-production records can be disposed of with reasonable profit, if well advertised. This necessitates having the dams tested for milk and butterfat production. Experience has shown that increased prices received for bulls from tested dams often more than pay for the testing.

SHIPPING BULLS.

For shipment by express, put bull in a strong crate, of proper dimensions. Animals may be injured or reach destination in bad condition otherwise, if shipped in poor crates. Figure 10 shows a well-constructed crate.[6]

Sufficient feed for the animal during shipment should be supplied by the shipper, with instructions for feeding and watering written on cardboard and tacked on the crate. A sack of hay and a quantity of grain, if the shipment is long, will meet the needs.

It may be advisable to have the bull insured against all hazards, for a period of from 30 to 60 days, the insurance covering the period of shipment and the time it takes him to get accustomed to new conditions. This insurance often will materially reduce the cost of shipping.

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[6] Plans and specifications for this crate will be sent free by the Dairy Division, United States Department of Agriculture, Washington, D. C., on request.

COOPERATIVE BULL ASSOCIATIONS.

Many farmers, on account of the small number of cows kept, do not find it profitable to keep a bull for their own use. If they buy a sire, he may be a cheap and inferior animal. These farmers should have the use of good sires without too great expense.

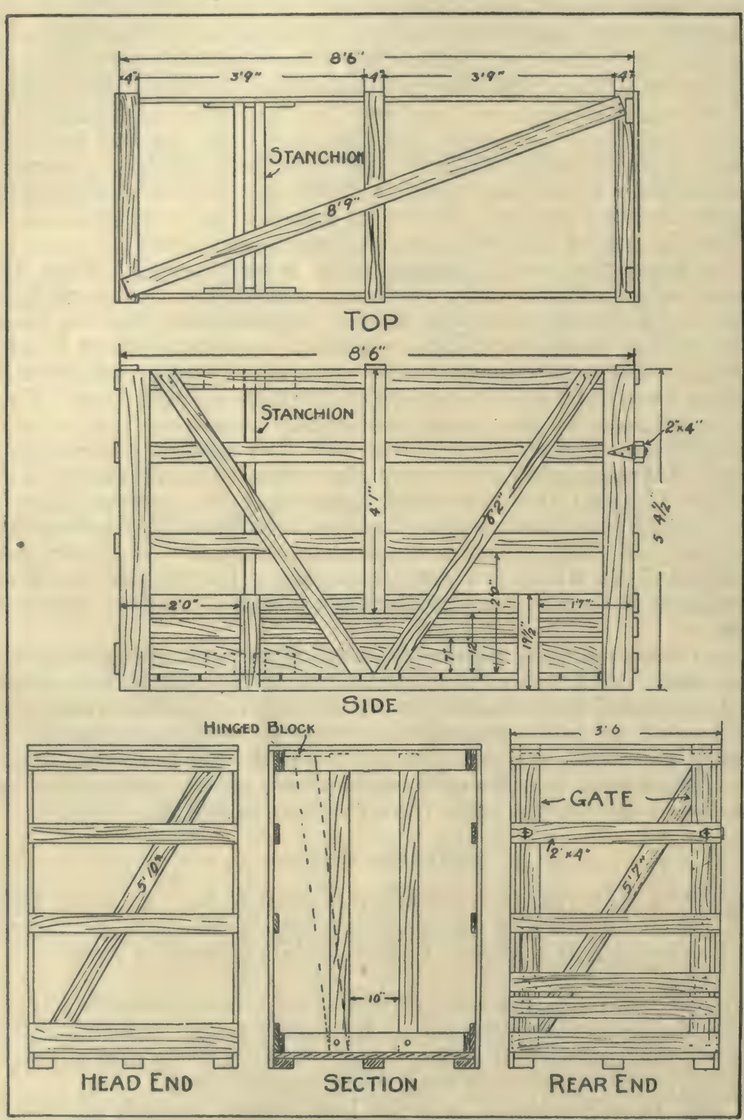

FIG. 10.—Plan of shipping crate. The size can be changed to suit the size of the animal.

Bull associations are designed primarily to enable these farmers to have an interest in, and the use of, good bulls at a cost within their reach, but many larger breeders also are taking advantage of them.

By this plan, several farmers in a community go together, buy purebred bulls, and use them cooperatively. The association is divided into breeding blocks, and a bull is kept on a farm centrally situated in each block, where the members take their cows to be bred. Every two years, the bulls are shifted from one block to another. This enables the members to obtain the service of high-class bulls for a period of years, limited only by the number of bulls in the association. This plan has been entirely satisfactory, and there are now in the United States 218 such associations, owning 956 purebred bulls.[7]

HANDLING THE BULL.

RINGING.

The ring is a safeguard in handling, and every bull should have one in his nose, even if he is regarded as gentle and easy to handle.

When the bull is between 8 months and a year old, a ring should be put in his nose. A copper ring 2 to 2¼ inches in diameter is satisfactory at this time, but it should be replaced by a larger and stronger gun-metal ring when he reaches 2 years of age. Rings are likely to wear out with use and age, and should be replaced. In case of especially unruly bulls, it is well to place two rings in the nose.

The ringing operation is not difficult, and can be done with but little trouble if gone about in the right way. Tie the bull's head fast so he can not jerk. Grasp his nose firmly, with the fingers or a nose lead. (Fig. 11.) Push a trocar, with cannula, through the cartilage that separates the nostrils. Then pull out the trocar, but leave the cannula. Put one end of the opened ring in the cannula, then withdraw the cannula, leaving the ring in the nose. Close the ring and replace the screw in it. File or sandpaper the joint until it is smooth. Do not tie the bull or lead him by the ring until the nose is healed and soreness gone, which will take from a week to 10 days.

Instead of trocar and cannula, some breeders use a sharp pocketknife with good results. There are also special nose punches on the market.

When about 2 years of age, replace the original ring with a larger and stronger one.

Occasionally a bull pulls the ring out, tearing his nose. (See fig. 12.) This is usually caused by sudden jerking on a tight rope, being tied too short, or getting the ring caught on something. An accident of this kind is rather serious, as there is no entirely satisfactory way to remedy the condition. In some cases, the ring is placed higher up, or the cartilage is pierced the opposite way and the ring placed in a vertical position. If this is done, it is not advisable to tie the bull by the ring, as it may be torn out again. Smaller rings may be placed on either side of the torn place, with a larger ring through them. This may work all right in some cases, but is not always successful, as the three rings may give the animal considerable trouble in eating, and get caught on things.

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[7] See Farmers' Bulletin No. 993, Cooperative Bull Associations.

If the nose is torn out, the bull should be confined in a stall and pen so arranged that it will not be necessary to handle him a great deal. If he is handled it should be done only with a strong chain or leather halter, which tightens across the nose when the lead rope is pulled. There are special halters on the market designed for cases of this kind.

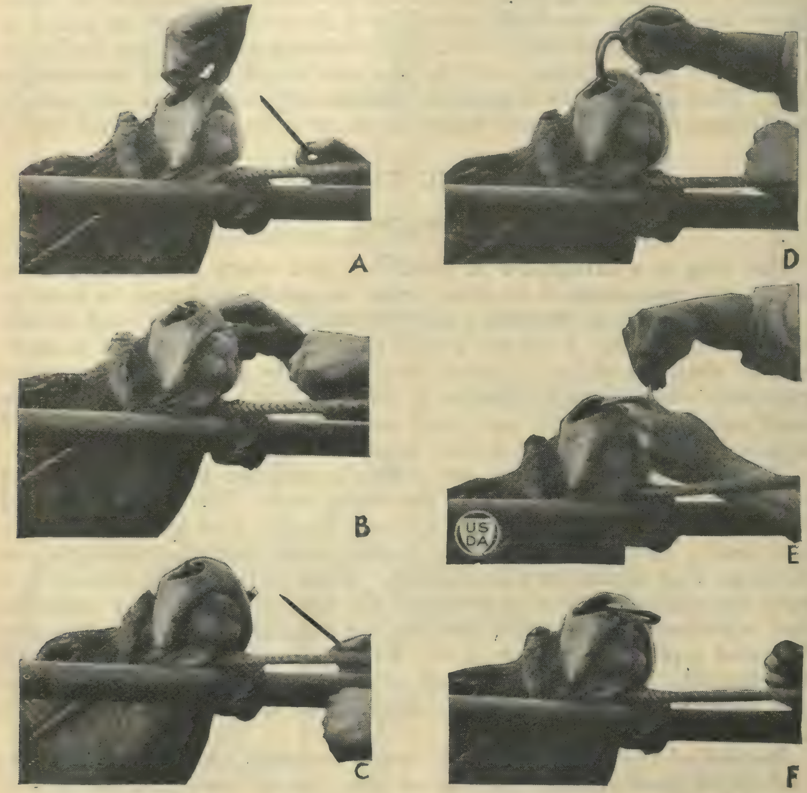

FIG. 11.—Ringing the bull.

HOBBLING.

If the animal is especially vicious, it is often advisable to hobble him when handling, so that if he starts to run or attack he can be thrown to his knees. Some breeders consider this a good method of "gentling." To hobble the bull, put a rope or band around his body, just behind the front legs. Have a loop or ring on this rope or band on each side of his body. Take another longer rope. Run one end through the loop, and tie the end to the pastern of a front leg. One person should lead the animal by a halter, while another holds the rope that is tied to his foot. When the animal starts, a strong, quick pull on the hobble rope usually will bring him to his knees.

THROWING OR CASTING.

It may be necessary, at times, to throw and tie a bull, for various reasons. This can be done with an inch rope—preferably cotton, which is softer and more pliable than hemp. The rope should be 40 to 50 feet long, depending on the size of the animal. One end is looped around the neck and tied with a rigid knot that will not slip. (See fig. 13.) Two half hitches are then taken around the chest and flank respectively, care being taken that the hitches are well down on the side of the body. By pulling steadily on the free end of the rope, the animal can be thrown. It may be necessary, if the animal is large, to have a second rope attached to one hind foot in order that the foot can be pulled under him, so that he can be rolled over on his side. (See fig. 14.) Have plenty of help at hand. Figure 15 shows the animal thrown, and his feet being tied.

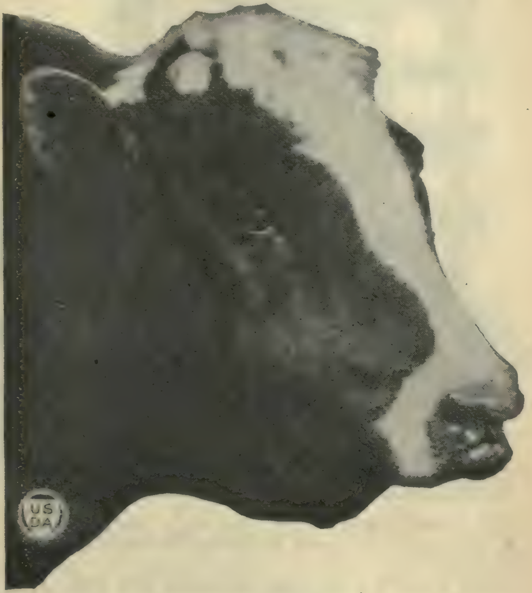
FIG. 12.—Bull from whose nose the ring has been torn out.

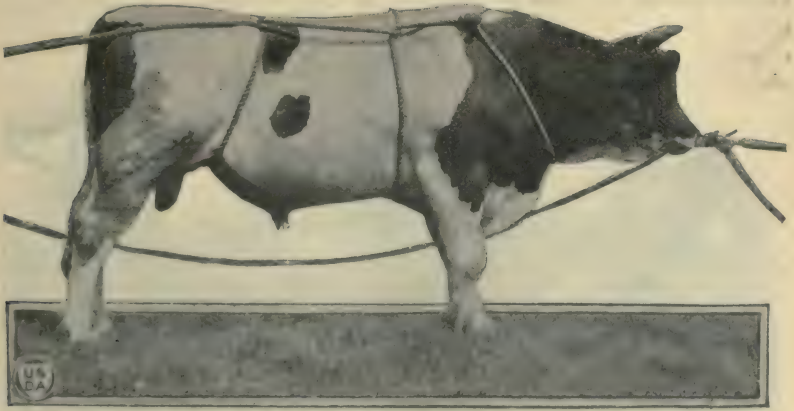
FIG. 13.—Throwing: Method of putting rope on. Half-hitches should be well down on side.

STOCKS.

Stocks are especially useful for holding bulls for dehorning, trimming the feet, and some other operations. They are strongly built crates into which the animals are led, and securely tied. (See fig. 16.) They should be of strong material, well bolted. The size should be 9 feet long and 6 feet high, with an inside width of 2 feet 4 inches. A heavy iron ring, to which the bull may be tied, is bolted to the floor about 2½ feet in front of the stanchion. A large or a small animal can be accommodated by shifting a heavy timber in slots at the rear made for that purpose.

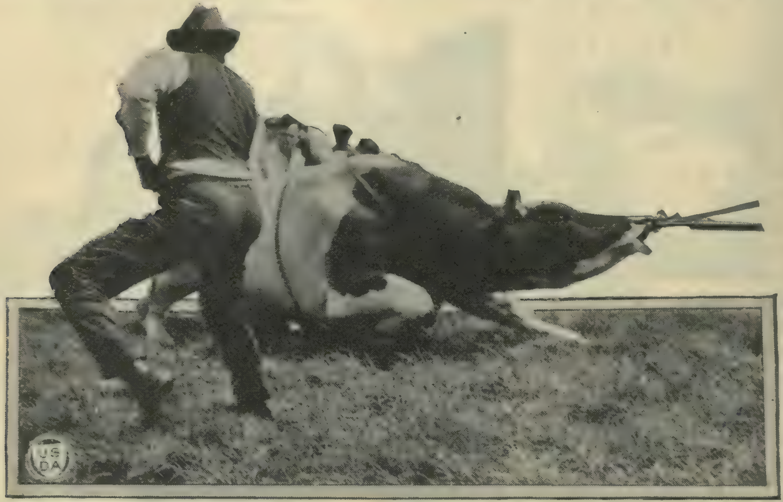

FIG. 14.—Throwing: Left hind leg is being pulled under body with a second rope, so that the bull can be rolled on left side.

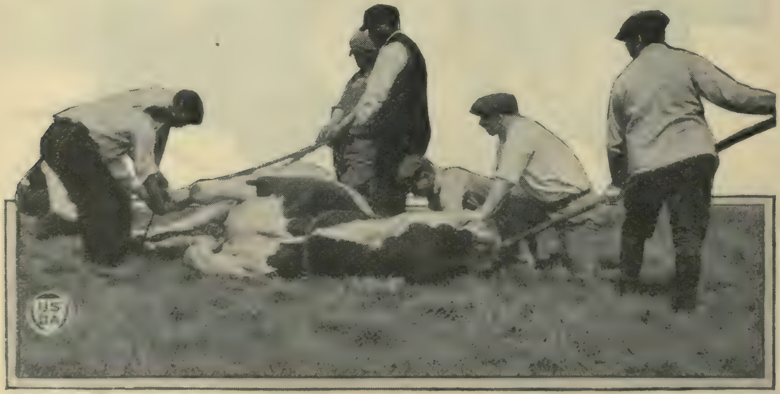

FIG. 15.—Throwing: Method of holding and tying feet.

Hospital stalls are sometimes constructed on the same principle, with a belt or a sling attached to a pulley above. The slings are passed under the animal, and his weight can be raised from the floor by means of the pulley and derrick. Then by tying his feet to the floor or uprights, he can be worked on with little danger of his getting loose. It is often difficult, however, to lead large or heavy animals into stocks and hold them there, in which case it may be necessary to throw them.

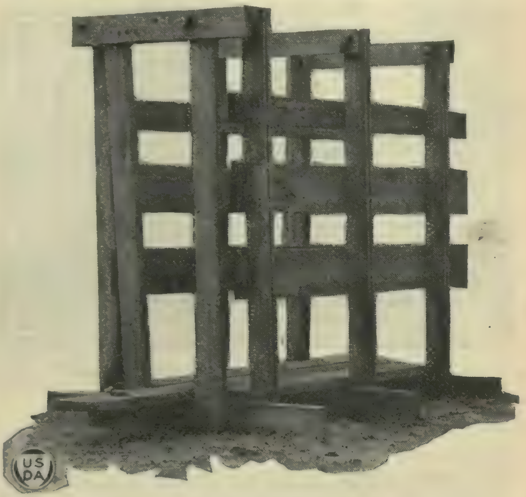

Fig. 16.—Stocks: These may be used for various purposes. Note iron ring bolted to floor in front of stanchion.

STAFF FOR LEADING.

The bull, when a calf, should be trained to lead, first with a halter, and later with a staff attached to the ring in his nose. (See fig. 17.) There are a number of good bull staffs on the market. They are equipped with locking devices, so that if properly handled there is little danger of their becoming unsnapped. A hand grip on the end aids materially.

CAUTION IN HANDLING.

Always handle a bull in a firm manner and never trust him. It often happens that a man is killed or injured as the result of taking chances. No matter how quiet and gentle a bull has been, he is likely to be in a bad humor at times. Never take a bull on a public highway, unless he can be kept under absolute control. Many serious

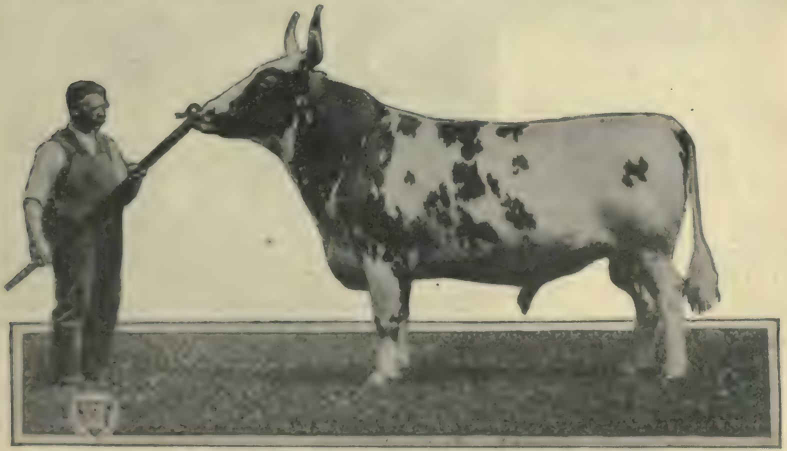

Fig. 17.—Proper way to hold bull with a staff.

accidents have occurred as a result of allowing so-called gentle bulls to graze along country roads, or driving them to and from pasture with the cows on public highways. Some States have laws prohibiting these practices.

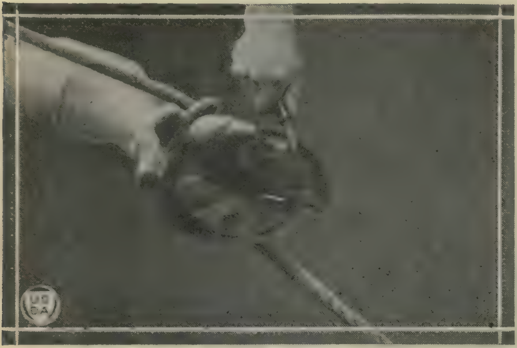

Fig. 18.—Trimming feet: Cutting out the sole. Note long toes.

FEET AND HORNS.

TRIMMING THE FEET.

Bulls kept in close quarters with little exexcise frequently develop long hoofs. This condition is not only unsightly, but may become painful, so much so that the bull can not stand or walk squarely. Then, too, it brings on various other foot troubles, such as foul foot and rot. The hoofs should be trimmed, or they will break off or disfigure the animal's feet. With young animals, this trimming often can be done with a long-handled chisel, while the animal is standing on a hard dirt or plank floor. The sole and the cleft between the claws can not be got at in this way, however, and oftentimes these parts cause the most trouble. In that event it may be necessary to throw and tie the animal.

A pair of pincers, like those used in shoeing horses, comes in handy in clipping off the toe of the hoof, or it can be sawed off with a fine-tooth saw. A shoeing knife can be used to trim out the sole and dead hoof, and then a rasp to smooth down the surface. (Figs. 18 and 19.) The dewclaws, which often grow to greath length, should also be trimmed off fairly close. (Figs. 20 and 21.)

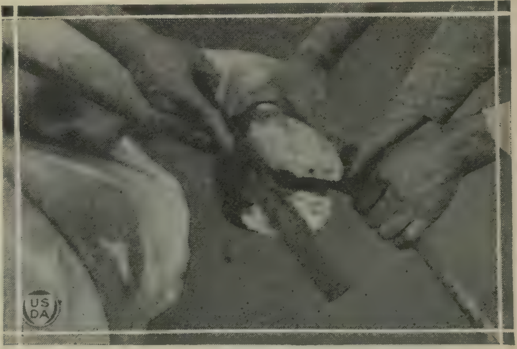

Fig. 19.—Trimming feet: Rasping.

DEHORNING.

In general, bulls to be kept for breeding purposes should not be dehorned as calves, because it is likely to affect their selling price. Breeders, as a rule, prefer bulls with horns. If old bulls are properly handled, it is seldom necessary to dehorn them. Dehorning, however, is often done to make an ugly bull more easy to handle. The animal preferably should be 2 years old before the horns are taken off; otherwise there is danger that false horns or scurs will develop. It is best to have a veterinarian or other experienced man do the dehorning.[8]

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[8] See Farmers' Bulletin No. 949, Dehorning and Castrating Cattle.

TRAINING HORNS.

It is often desirable to train the horns of younger bulls, in order to get the shape typical of the breed. The best time to begin is when the bulls are quite young. There are several devices that can be bought or made to suit different kinds of horn development.

TRIMMING AND POLISHING HORNS.

One may want to trim and polish the horns. This can be done with a rasp, pieces of glass, and fine sandpaper. The rasp should be used first to smooth off the dead tissue and uneven places, followed by scraping with the edges of freshly broken glass. The scraping should always be with the grain, and not across. Fine sandpaper should make the horn smooth and ready for polishing. Apply linseed oil and pumice stone, or metal polish, and polish with flannel cloth or chamois skin.

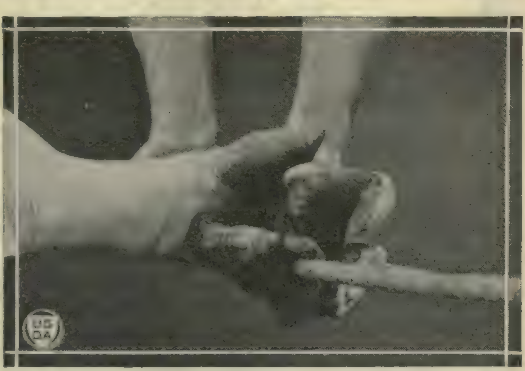

FIG. 20.—Trimming feet: Note the long dewclaws.

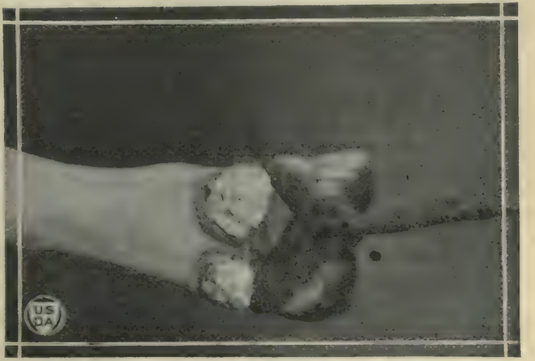

FIG. 21.—Trimming feet: Dewclaws properly trimmed.

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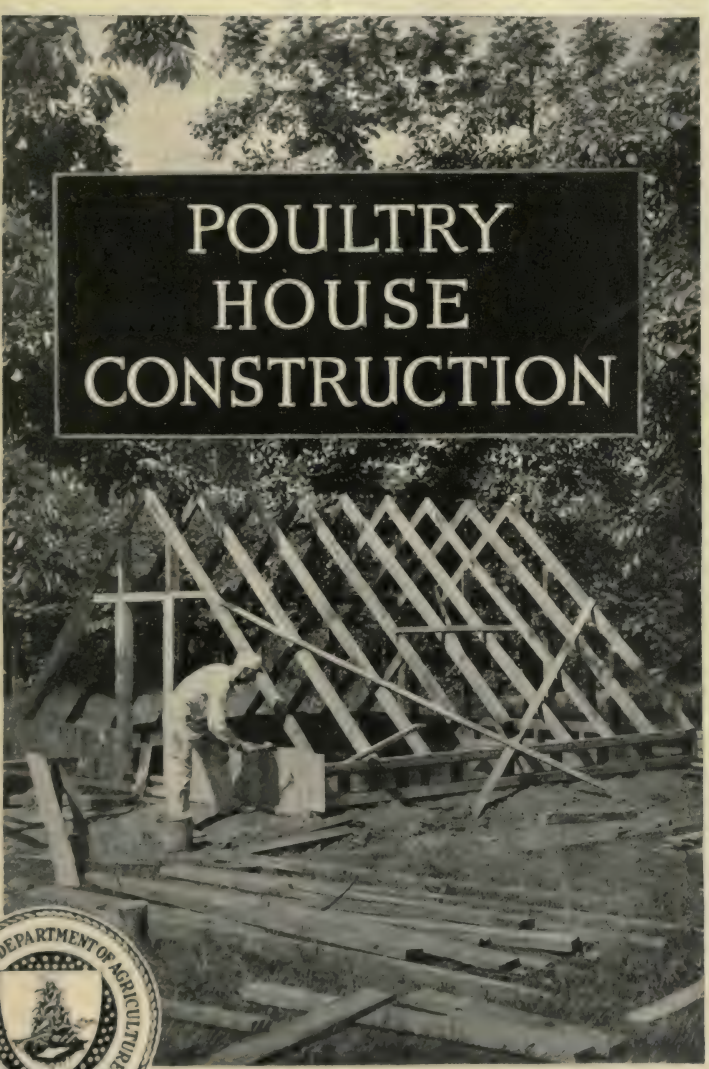
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1413

POULTRY HOUSE CONSTRUCTION



HENS need a comfortable house, one that is dry and roomy, with plenty of fresh air and sunlight. It never pays to overcrowd them.

A plain shed-roof house is most economical, and most satisfactory. It should be so arranged that it will be easy to clean and for general convenience.

It is easier to keep the birds healthy, and to reproduce the stock under the colony system, if the birds are allowed free range. Breeding stock, and especially growing chickens, should have plenty of range. Hens used solely for the production of market eggs may be kept on a very small area.

Detailed information on how to build, and working plans of various types of poultry houses, are given in the following pages. With these anyone handy with tools can build similar poultry houses.

This bulletin is a revision of, and supersedes, Farmers' Bulletin 574.

Washington, D. C. September, 1924

POULTRY HOUSE CONSTRUCTION

By Alfred R. Lee

Poultryman, Animal Husbandry Division, Bureau of Animal Industry

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ESSENTIALS IN POULTRY HOUSES

THE IMPORTANT CONSIDERATIONS in building poultry houses are fresh air, dryness, sunlight, economy of labor, and space enough to keep the birds comfortable.

Fresh air is essential. Hens will do well in a cold house, provided the house is well ventilated. Dryness is necessary. Not only should the building be tight to keep out the rain, but the moisture from the chickens within the house must be carried off by ventilation. The more sunlight in the house the better, as this helps to dry out the moisture and also makes the building more sanitary. As labor is a big item, arrangement of the house for convenience in labor adds greatly to the chances of success. Hens to do well need sufficient roosting and floor space, so they will be comfortable at night and will exercise freely during the day.

Different styles of houses are used successfully in all sections of the United States. A plain shed-roof house with openings in front and rear, according to climatic conditions, is well adapted for any section of the country. In the South the houses may be less tight and the front should be much more open than in the North. Many of the State agricultural colleges have plans for poultry houses which are especially recommended for their respective States.

LOCATION AND SITE

The location should have good drainage of water and air, so that the floor and yards will be dry. The house should not be in a low pocket or hollow in which cold air settles. Wherever possible a southern or southeastern exposure should be selected, although this is not so vital if there is any good reason for facing the house in some other direction. The common practice in most sections of California is to face houses east on account of winds and storms.

Poultry can be raised successfully on any well-drained soil. A light loam which will grow good grass is well adapted for this purpose, while a very light sandy soil through which water leaches freely is best adapted for intensive poultry keeping. Most of the green feed for fowls kept on such a soil will have to be purchased. A heavy clay or adobe soil is not well adapted to poultry raising, as such land does not drain readily, which makes it much more difficult to keep the stock healthy.

TYPES OF BUILDINGS

There are two general types or arrangements of poultry houses—long, stationary houses, holding from 500 to 1,500 hens, and small, movable houses (colony houses), which are scattered over a wider area. Many poultry farms use both types, the long house for the laying flock and the smaller colony houses for the breeding stock.

The long, stationary house, or the intensive system, saves steps, but it is easier to keep the birds healthy and to reproduce the stock under the colony system, where the hens are allowed free range. Breeding stock, and especially growing chickens, should have abundance of range, while hens used solely for the production of market eggs may be kept on a very small area with good results.

The colony-house system necessitates placing the houses, each holding about 100 birds (including hens and growing chickens), from 150 to 200 feet apart, so that the stock will not kill the grass. The colony system is practicable only on cheap land, or where it can be combined with stock raising, using the pasture both for poultry and for livestock. Fences can be placed around each colony house to keep the livestock away from the poultry feed and water.

One of the most common arrangements for a long house for laying hens is to have large yards on both sides, making each yard 150 feet deep and the length of the house. Smaller houses can be used to advantage in combination with this for the breeding stock, giving them either free range or more yard space. The long houses are also used by many persons for breeding stock, but the birds do not usually make such good breeders as those kept in colony houses with more yard space.

YARDS AND FENCES

Fences dividing the land into yards increase the cost of equipment, labor, and maintenance. Fences should be few. Land can be cultivated and kept sweet more easily if not fenced, and the value of fresh, sweet land for poultry can hardly be overestimated. A good grass sward can be maintained on fertile soil by allowing from 220 to 260 square feet of land per bird (200 to 167 birds to the acre). More space per bird is necessary on poor or light land. A much larger number of fowls is usually kept to the acre on sandy soil, where double yards are used and the land is frequently cultivated. Under this system as many as 1,000 laying hens are sometimes kept on 1 acre, for egg production only, when the stock is not used for breeding and no chicks are raised.

The general-purpose and meat breeds in small yards require fences from 5 to 6 feet high, while a fence 6 to 7 feet high is necessary for Leghorns. To keep Leghorns in, it may help to slant the upper 2 feet of the fence in at an angle of about 30°. A strand or two of barbed wire strung on top of the woven wire is good. It is sometimes necessary to clip the flight feathers of one wing of those birds which persist in getting out. A board or wooden strip along the top of the fence is not advisable, as hens will often fly over such a fence.

Posts may be set or driven. They should be from 8 to 10 feet apart for common hexagonal poultry netting, or 16 to 20 feet for woven wire. Woven-wire fencing makes a better-looking fence, and will last much longer than the common poultry netting. Corner posts should be about 8 inches in diameter, set 4 feet in the ground. Line posts may be 4 or 5 inches in diameter, set 3 feet in the ground.

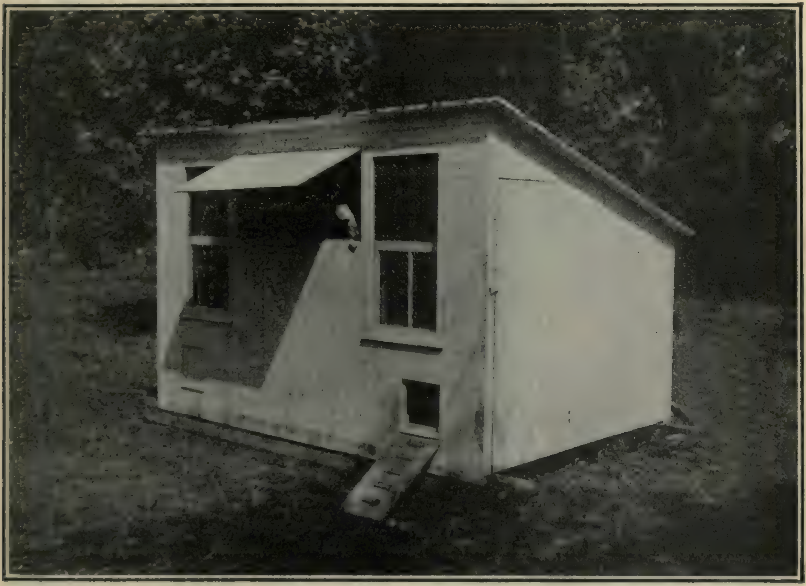


FIG. 1.—Colony house used at the U. S. Experiment Farm, Beltsville, Md. This house is built on runners so that it can be easily moved. (See figs. 2, 3, and 4.)

Light posts, driven down, are all right for temporary fences. Treating the ends that will be below ground with creosote or other preservative will make the posts last longer. Brace the corner posts, or set them in concrete, or do both.

SIZE AND CAPACITY OF HOUSES

A house so built that the attendant can stand up and work conveniently will have enough cubic air space, if from 3 to 5 square feet of floor space per fowl is allowed. Provide fresh air by ventilation; large cubic space in a house is not a substitute for ventilation. The extent of floor space necessary depends on the system, size of pens, weather conditions, and size of the birds. More birds can be kept on a small floor area under the colony system than under the intensive system, where the climate is mild and the hens have free range most of the year. Three square feet of floor space per bird should be allowed with good-sized flocks of Leghorns and 4 square feet with general-purpose breeds, increasing this to 3½ square feet for Leghorns and 4½ square feet for general-purpose breeds when flocks are small. Three square feet is enough for Leghorns and 3½ square feet for the general-purpose breeds when kept in colony houses with free range in a mild climate.

Colony houses accommodating from 30 to 50 hens or nearly grown chickens are about as large as can be moved easily, but larger numbers may be kept in one flock in a long house. Flocks of from 100 to 500 are well adapted to average conditions for the production of market eggs. Large flocks require less labor, fewer fences, and a lower house cost than small flocks, but there is a greater risk of disease, and the individual hen receives less attention.

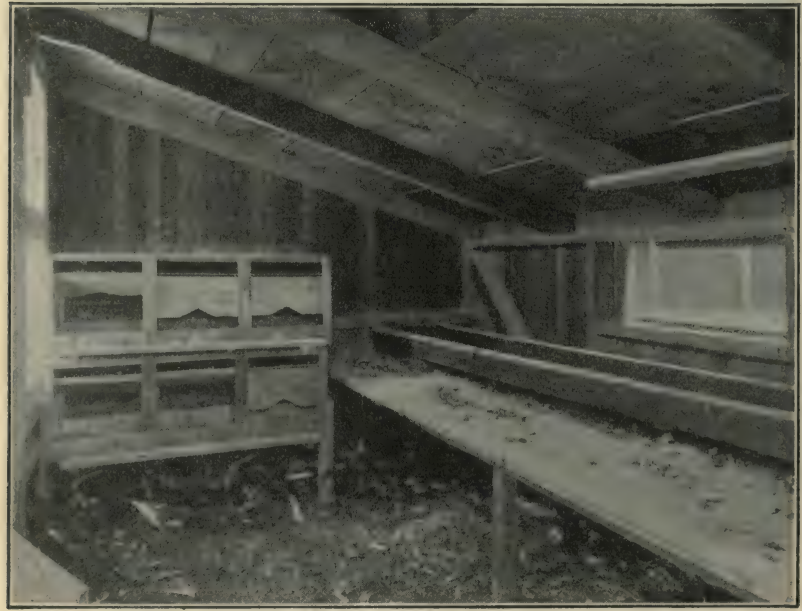
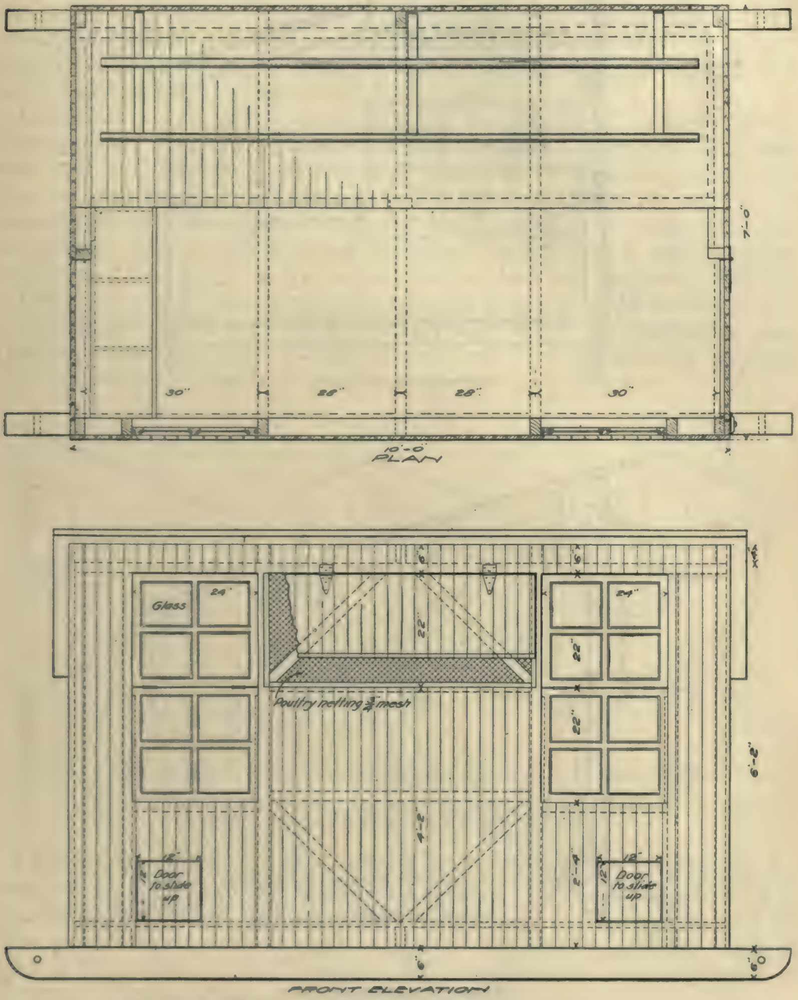


FIG. 2.—Interior of colony house used at U. S. Experiment Farm, Beltsville, Md.

Figure 1 shows a colony house which is 10 feet long and 7 feet deep. This house is used extensively on the United States Experiment Farm, Beltsville, Md. The capacity of this house is 25 hens, where used either on free range or with good-sized yards. The house is built on runners, so it can be moved to fresh soil every year or two. Interior view, detailed plans, and bill of material of this house are shown in Figures 2, 3, and 4.

COST OF BUILDING

On a basis of 4 square feet per hen, substantial poultry houses can be built for from $2 to $2.90 per head, including labor. The cost of material per head varied in 1923 from $1.25 to $1.75. When the labor is hired it costs at least two-thirds as much as the material, and in some cases equals the cost of the material. Bills of materials are given with the different plans of houses in this bulletin.



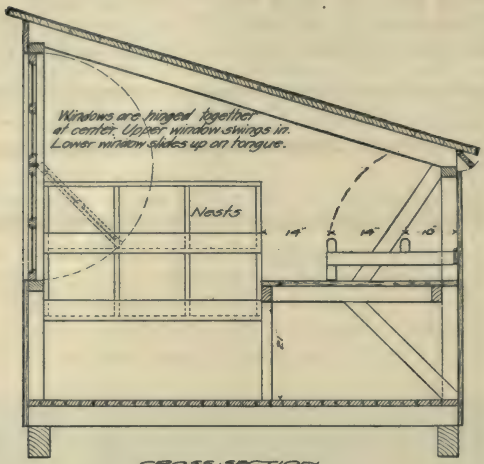
Note: Sills (runners) 4"x6"; joists & rafters 2"x4"; plates studs & braces 2"x3"; siding & flooring ⅞" tongue & groove material and roof ⅞ material covered with roofing paper.

FIG. 3.—Floor plan and front elevation of colony house used at the U. S. Experiment Farm, Beltsville, Md. Capacity, 25 hens. (See figs. 1, 2, and 4.)

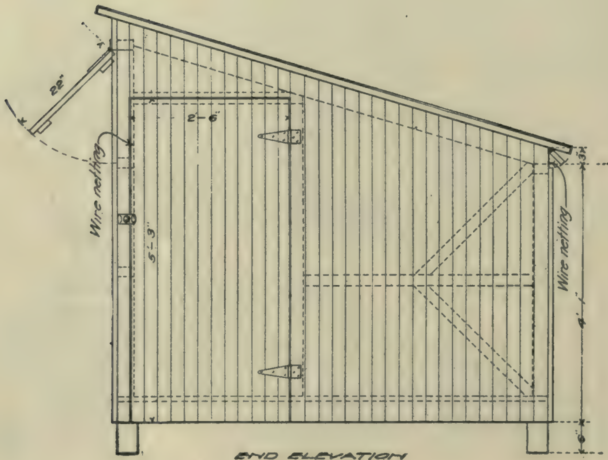
DETAILS OF POULTRY-HOUSE DESIGN

ROOF

The roof should be water-tight. Shingle roofs should have a one-third pitch. Composition or metal roofs may have a less pitch or be


Windows are hinged together at center. Upper window swings in. Lower window slides up on tongue.
Nests
14"
14"
10"
21"

CROSS SECTION



END ELEVATION

BILL OF MATERIAL FOR COLONY HOUSE

USE	SIZE	Nº OF PIECES	LENGTH FEET	BOARD MEASURE
Sills (runners)	4"x6"	2	12'	48'
Joists	2"x4"	3	14'	28'
Studs & braces	2"x3"	13	12'	78'
Rafters	2"x4	3	16'	32'
			Total	186'
7/8" Matched flooring (floor & sides)				340'
7/8 Sheathing, surfaced one side.				100'
Roofing paper, 1 roll.				
Windows hardware etc.				

FIG. 4.—Cross section and end elevation of colony house used at U. S. Experiment Farm, Beltsville, Md. Capacity, 25 hens.

almost flat. However, the greater the slope the longer the life of the roof. Different types of roofs are illustrated in Figure 5.

The shed or single slope roof is practical for houses up to 20 feet in width if a girder and posts support it. A girder is needed only in shed-roof houses wider than 14 feet. Twenty feet is as wide as is ordinarily advisable for a house for laying hens, unless there is an aisle. The shed-roof type is practical and easy to build. It allows a high front to the house, and prepared roofing will last longer on a north slope than on a south one.

The combination or two-pitch roof of uneven length, and the semimonitor roof (fig. 5) are adapted for buildings from 16 to 24 feet wide, while either of these styles, or the monitor and the gable roofs may be used for wider buildings. The combination roof on a house more than 16 feet wide gives good head room at a moderate cost, reduces the amount of surplus air space, and makes a good-looking building. The shed-roof type is cheaper but not so good looking.

The semimonitor and monitor types are best for wide houses which have a central alley, and are commonly used for large brooder houses. The semimonitor house usually faces south. The monitor type of roof is frequently used on buildings facing east and west.

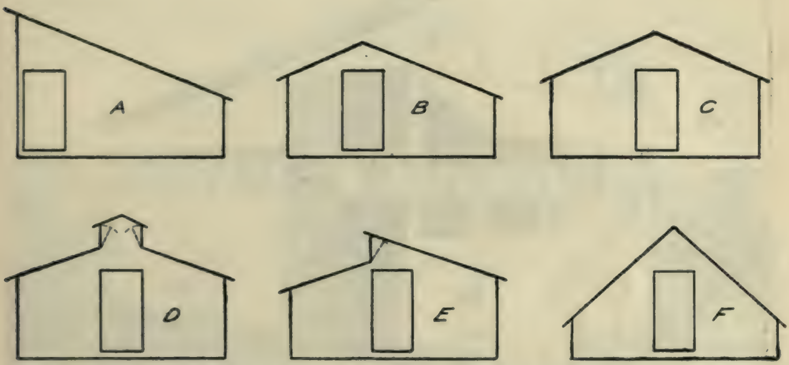


Fig. 5.—Types of roofs for poultry houses. *A*, shed; *B*, combination; *C*, gable; *D*, monitor; *E*, semimonitor; *F*, A-shaped

The gable roof is used extensively for two-story buildings, for brooder houses, and for incubator cellars. This style of roof is usually ceiled at or slightly above the eaves, or the gable may be filled with straw or some kind of absorbent material, which tends to keep such houses dry and warm. If straw is used, there should be an opening in each gable to allow air circulation.

The A-shaped roof is used for growing coops and colony houses. With a wall 18 inches high it provides a large amount of floor space with a minimum of lumber, but increases the roof surface, which is the most expensive part of the house.

FRONT AND REAR

A house with the entire front open is commonly used in the South. One in which from one-fourth to one-third of the front is curtains and windows is used in the northern part of the United States. Curtains and windows make up from one-third to one-half of the front of the house in the sections between these two extremes. The openings in the front are covered by glass and muslin curtains, so that the amount of open space can be varied according to the season and weather conditions. Glass is most essential in the North, and some glass in the front is desirable in all but open-front houses.

Wooden shutters or wind bafflers are sometimes used in the front of the poultry house, providing an opening through which the air can always circulate without allowing rain to beat into the house. The main objection to these shutters is that they shut out sunlight.

Windows in the rear of the poultry house, between the floor and the dropping boards (as shown in figs. 14 and 16), are desirable in wide houses. They let more light in on the floor, and help to keep the litter better distributed, as hens always scratch the litter away from the light.

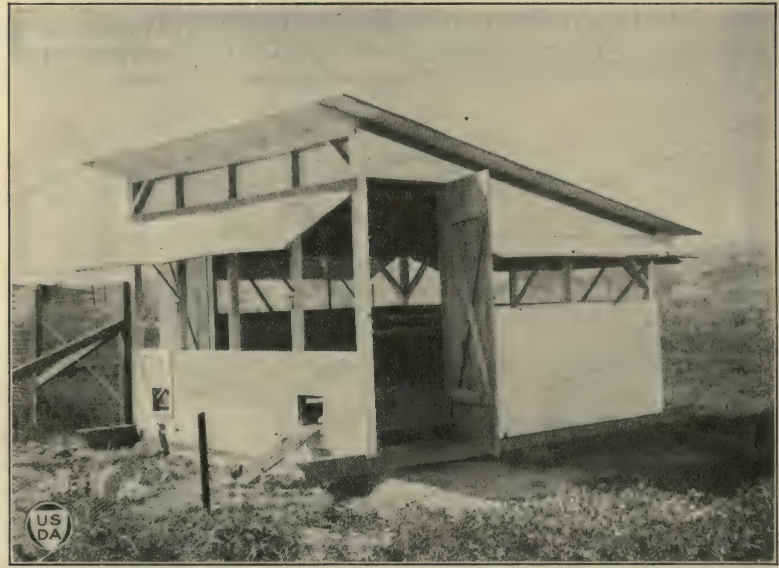


FIG. 6.—Shed-roof house used on the U. S. Experiment Station, Glendale, Ariz. This house is especially adapted for extreme southern conditions. It is 12 by 12 feet and will accommodate about 40 hens

A weather shield, 2½ to 3 feet wide, extending downward like an awning at an angle of 45 degrees from the top of the front, prevents rain from beating into the house. Such shields are particularly good where prevailing rains come from the south.

In order to give extra ventilation in hot weather, in the latitude of Washington, D. C., and all places south of that, there should be an adjustable ventilator opening in the rear side of the house. This opening is usually made the entire length of the house, between the plate and the eaves. It must be made so that it can be closed tightly in cold weather. Such an opening is shown in Figures 4 and 13.

A type of house, with openings on all four sides, for use in the extreme South, is shown in Figure 6. This is a colony house, built on runners so it can be moved, and has a wooden floor. The openings have shutters which provide shade and also keep rain from beating in. Protection from the sun is as essential in the extreme South as protection from rain. The front shutter covers only part of the front openings, but is large enough to keep out the rain.

A large amount of glass in the front of the house makes the house warm during the day and cold at night, as glass radiates heat very rapidly. Unbleached muslin, or a light weight of duck cloth, is used for curtains in the fronts of poultry houses. This cloth should be thin enough to allow a slow circulation of air without a draft, but the object is defeated by using too heavy a grade of duck or by oiling or painting the cloth.

The front of the house should be high enough so that the windows or openings will allow the sun to shine well back into the house during the winter. The depth which the sun's rays shine on the floor of the house in the vicinity of Washington, D. C. (latitude 40° N.), on January 1, is given in the accompanying table.

Top of windows	Depth of sunshine	Top of windows	Depth of sunshine
Ft. in.	*Ft.*	*Ft. in.*	*Ft.*
3 6	8	6 2	14
4 5	10	7 1	16
5 4	12	7 11	18

FLOOR

As to what kind of floor is best depends on the size and use of the house, on the slope of the land where the house is to be located, and on the soil.

Concrete floors usually are the best for long, permanent buildings, brooder houses, incubator cellars, and all permanent houses where an artificial floor is required and can be built on the ground level. Concrete floors are easy to clean, very sanitary, rat proof, and comparatively inexpensive if gravel and sharp sand are cheap. Keep concrete floors well bedded with straw or some kind of litter, especially in winter, so they will be dry and not too cold.

The floor generally is made of lumber where the floor level will be from 1 to 3 feet above the ground, or where the land is very uneven or sloping. Board floors too close to the ground make rat harbors, and rot out. They should be high enough off the ground to let dogs under, and to permit circulation of air to keep them dry. Portable houses commonly have board floors.

A dirt floor may be used on very light, sandy, dry soils, especially for small, or colony, henhouses. Dirt floors should be from 2 to 6 inches higher than the outside ground surface. It is advisable to take out the old dirt once a year and replace it with fresh sand or fine gravel and earth. Dirt floors harbor rats. Also, they are very dusty when the hens are scratching vigorously in the litter. Litter does not last nearly so long on a dirt floor as on either a concrete or wood floor.

PARTITIONS

The lower 3 feet of partitions may be solid and the upper portion wire netting, or solid partitions may be used. Partitions extend across the house every 25 to 40 feet, depending on the length of the house. Some solid partitions are necessary in a long house; otherwise the house will be drafty and the birds apt to catch cold.

There should be partial partitions extending out from the back wall of the house at least as far as the front edge of the dropping boards, and solid from floor to roof, and 20 feet or less apart. This prevents a draft on the birds when on the roost at night, and also keeps the birds from overcrowding in one section of the roost.

ROOSTS, DROPPING BOARDS, AND NESTS

The interior fixtures of the pens should be simple, inexpensive, and easy to clean. Roosts and dropping boards may be made removable, but it is simpler and just as satisfactory to make them permanent, with as few cracks and hiding places for mites as possible. The use of carbolineum or a wood preservative of this nature on the roosts and roost supports makes it unnecessary to make these fixtures removable except in the South.

Roosts are usually placed next to the end or back walls, 4 to 8 inches above the dropping boards, while the dropping boards are from 20 inches to 2 feet 9 inches above the floor. The roosts should all be on the same level; otherwise the birds will crowd and fight to get on the highest. Scantlings 2 by 3 inches or 2 by 4 inches with the narrow surface up and upper edges rounded off make good roosts. Seven inches of roost space per fowl should be allowed for Leghorns and 10 inches for Plymouth Rocks or birds of that size, while larger fowls require still more roost space. As many roosts should be used as are necessary to accommodate the fowls comfortably, two roosts generally being used in narrow houses and three, four, and sometimes five in wide houses. Roosts should be placed about 13 inches apart for Leghorns and 15 inches apart for Plymouth Rocks, but the outside ones may be within 10 inches of the edge of the dropping boards.

Nests may be placed on the partition, end walls, or under the dropping boards, but should be high enough above the floor so that the fowls can work under them. They should also be arranged so that the hens can get into them easily. The nests should not be placed under the edge of the dropping board if there is any other place where they can be arranged, as placing them there makes the space under the dropping boards dark and makes the nests more likely to get dirty and more subject to infestation with insects. The nests should be from 12 to 14 inches square and high, depending on the size of the hens, with a strip about 4 inches high on the open side to retain the nesting material. One nest should be provided for every four or five hens.

Trap nests are essential in any careful breeding work, such as pedigree breeding or the breeding of exhibition poultry. A trap nest is a laying nest so arranged that the hen can not get out of it until released by an attendant.

MATERIALS FOR BUILDING

Wood is the cheapest and most commonly used material for building poultry houses. A building constructed of wood can be moved and torn down, or changed, more readily than one constructed of hollow tile or concrete. Any durable lumber available may be used. The lumber for the outside construction should be well seasoned; otherwise the shrinkage will leave cracks in the walls.

Hollow tile makes a good poultry house, and it can be bought in some sections at a price which, considering its durability, compares favorably with the cost of wood. This construction is well adapted to incubator cellars and brooder houses, or to any buildings requiring double walls and good insulation. It is not desirable for small poultry houses which may be torn down or moved. Houses made entirely of solid concrete are cold and damp.

CONSTRUCTING THE HOUSE

FRAMEWORK

The framework consists of the sills, which support the building; the studs or uprights, which rest on the sills; the plate, which is on top of the studs, and the roof rafters, which rest on the plate.

The sills are placed on posts, stones, or concrete supports, or directly on top of concrete walls.

Wooden floors should be from 1 to 3 feet above the ground. Concrete floors are laid directly on the ground. (The site should be elevated enough so that there is good drainage away from the building.)

Wooden posts should be from 6 to 8 inches in diameter, placed 6 to 8 feet apart, and 2 to 3 feet in the ground or below the frost level. Concrete posts may be used in place of wooden posts, and are much more durable, as wooden posts will rot out after a few years. Cedar, locust, chestnut, redwood, and cypress make the best posts.

Sills may be either 2 by 4 inches, or 4 by 4, depending on the size and construction of the building, 2 by 4 inches being heavy enough for colony houses or those of light, single-wall construction which are not over 10 to 12 feet deep and 4 to 7 feet high. Sills 4 by 4 inches are used for larger buildings and for houses with double walls. Sills 4 by 6 inches are used in two-story henhouses, or other large poultry buildings, and should be set on edge, unless on a concrete or stone wall, when a lighter sill may be used and laid flatwise. Concrete walls are commonly used as foundations for large poultry houses, with a 2 by 4 inch sill, which is bolted to the walls. The posts or supports must be set close together if light sills are used.

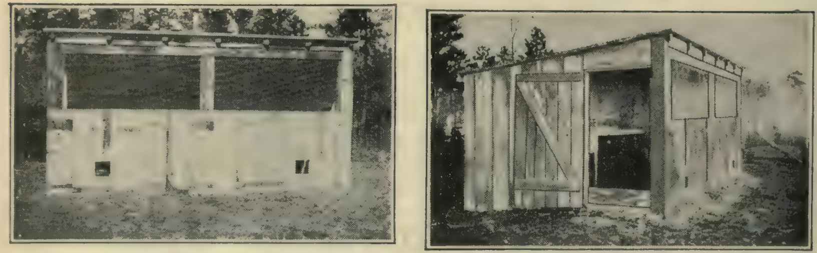
Runners 3 by 4 inches, or 4 by 6, are used as sills for portable houses, which require heavy framework. Portable houses which are to be moved on runners must be braced extra well in the corners to stand the strain of moving.

Floor joists may be of 2 by 4 or 2 by 6 inch lumber, depending on the span. They should be from 16 to 20 inches apart. If the span is over 10 feet a center support should be used for 2 by 4 joists.

Virginia pine is commonly used for sheathing in the North, hard pine in the Gulf States, and redwood or Oregon pine on the Pacific coast, while local pines of different kinds are available for rough lumber in many sections. Secondhand lumber (see fig. 7), or lumber from large packing or piano boxes, may be used in building small houses, and may often be bought cheaply. Oregon, Georgia, and North Carolina pine, chestnut, and oak are used for sills and runners. Lumber comes in even lengths, usually 10, 12, 14, and 16 feet long. If secondhand lumber is to be used, it is advisable to plan the house according to the length of the lumber. Care should be taken

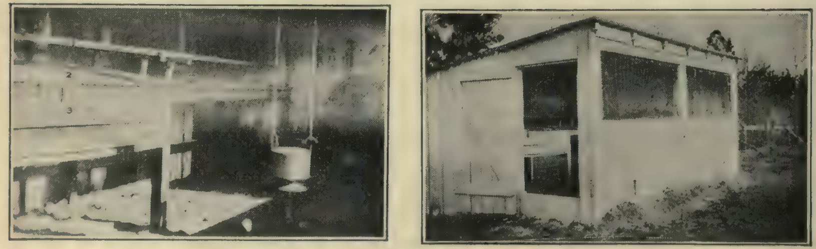
Old-style henhouse. No light; no ventilation; poor results

Old shed. Excellent material for poultry house



Open-front henhouse. Shed boarded up in front; poultry-netting windows

Side view of house constructed from old shed



Interior of same house. Good sunlight conditions. 1, Movable roosts; 2, dropping board; 3, nests

Model henhouse constructed from shed at little cost. Note effect of a coat of whitewash

FIG. 7.—How old buildings may be converted into good poultry houses

in ordering a bill of lumber to specify lengths which will cut with the least waste.

To square the corners of a small poultry house, fix one line or side of the proposed house. With this as a base, locate the other corner posts by using the 6, 8, and 10 foot combination, measuring 6 feet from one end of the fixed line and 8 feet from the same end at right angles. The angle between the two lines is fixed by a rule 10 feet long running from the 6-foot mark of the fixed line to the end of the 8-foot line, thereby making a square corner. A triangle whose sides are 6, 8, and 10 feet long, respectively, contains a right angle opposite the diagonal side.

The sill in small buildings may be made level by driving a stick at one corner of the house, to which a straightedge or a long, straight stick is nailed at the desired height of the posts or sill. A spirit level is used on this straightedge to mark the posts at the right height or to make the sill level. A transit is generally used in laying out large buildings.

The studding is toe-nailed on the sill. It should be set plumb with a spirit level and braced well until sheathed. Sills and plates are halved or spliced and nailed together at the joints or ends. These joints should be made over a post or stud. Plates are spiked to the top of the studding. Studding is set from 2 to 4 feet apart for the rear walls and is placed to fit the windows, curtains, and doors in the front and ends. Studs 2 by 4 inches are commonly used. In large houses the corner studs are generally doubled, making them 4 by 4. Two-by-three-inch studs are used sometimes, especially for movable houses. for the sake of weight; the 2 by 3 studs cost practically the same as the 2 by 4, so the only advantage in buying it is its lightness. The studs should be placed so that the lumber, which ordinarily comes in even lengths, will cut with little waste. Less studding is required if the building is boarded up and down rather than horizontally, as in the former case only a few studs with cross-studding or ties are required.

Figure 8 shows a shed-roof laying house, in which the boards are nailed up and down and which has very little studding, as shown in the detailed plans in Figures 17 and 18.

Plates are 2 by 4 inch scantling, laid flat on top of the studs, or 4 by 4 made by spiking two 2 by 4s together.

Rafters may be 2 by 4 inch or 2 by 6. The 2 by 4s are used only in light buildings where the clear span is not more than 12 feet and 2 by 6s for longer spans and in climates where roofs have to bear much snow.

It is advisable to use a purlin in buildings where rafters are more than 14 feet long. Purlins are usually made of 2 by 4 or 2 by 6 inch material set on edge on posts to support the roof. They are placed lengthwise of the house about midway the length of the rafters, which rest on them. In a deep house, which has a wide dropping board, the purlin may be placed at the front edge of the dropping board, so that the posts supporting the purlin will not be in the way in the pens. (See fig. 16.)

In roofs that go up to a comb a ridge board may be placed between the ends of the rafters to keep the ridge straight and even, but this is not necessary in most poultry houses. Collar beams or crossties

1 by 6 inches are used to prevent the spreading of the rafters on gable or combination roofs. They should be placed as low as possible on the rafters, so as to stiffen the frame, but not so low as to interfere with head space. If the hens roost on them, cover them with wire.

In erecting the rafters one pair may be set in position and the rest marked from these. Rafters should be notched only deep enough to make a snug fit and to provide good nailing on the plates.. Deep notching weakens them. Rafters are usually spaced 2 or 2½ feet apart, from center to center, so that the sheathing will cut with minimum waste.

FLOORS

Most concrete floors are damp and cold, and therefore must be heavily covered with litter. This is especially true of concrete floors laid directly on the ground. The land should be graded so that the water drains away from the house, as it is absolutely esssential to keep the floor of the poultry house dry.

The best concrete floors are made by first putting down a firmly tamped foundation of cinders, broken stone, or gravel not less than 6 inches thick, and then laying on it from 3 to 4 inches of concrete. A layer of tarred building paper, lapped and cemented with tar at the seams, may be laid between the stone foundation and the concrete to prevent moisture from coming through the earth and concrete and making the floors damp. Care should be taken not to break holes in the paper.

For concrete floors and walls use good-quality Portland cement, which should be kept in a dry place until used. Cement that has become damp and caked is worthless. A concrete foundation wall is always made for a concrete floor. This wall should go down deep enough to be below the ordinary frost depth. Where the wall extends above the ground level a form must be made, which is taken away as soon as the cement hardens.

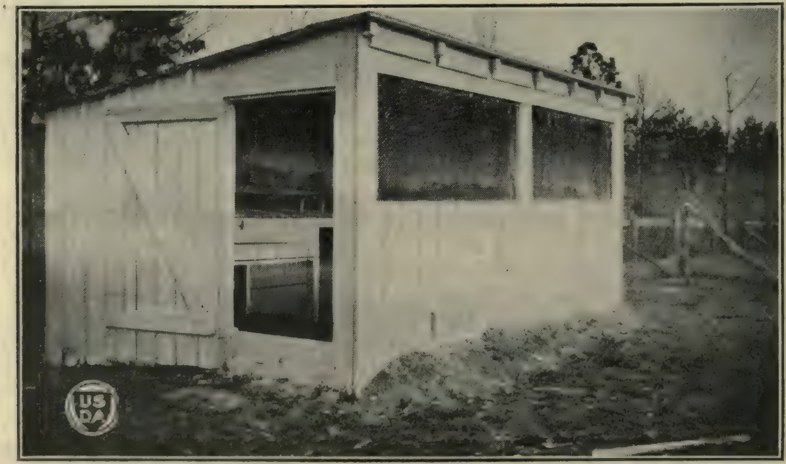


FIG. 8.—Shed-roof laying house of a plan similar to that shown in Figures 17 and 18

The cement should be mixed with clean, coarse sand which does not contain more than 10 per cent of clay or silt and with clean, broken stone or gravel ¼ inch to 1½ inches in diameter. If bank gravel is used, it should be screened through a ¼-inch mesh wire screen and the coarse material left on the screen used as large aggregate. The material which passes through this screen is sifted through a 40-mesh wire screen to eliminate dirt and fine sand. Any material which goes through the 40-mesh wire is thrown away. Sifting bank gravel and remixing the sand and gravel in the right proportions will usually save enough cement to pay for the cost of screening. Detailed information on the use and mixing of concrete is given in Farmers' Bulletin No. 1279, "Plain Concrete for Farm Use."

A mixing platform with a smooth surface and a bottomless box with a capacity of 2 cubic feet for measuring the sand and gravel are necessary for preparing concrete. Spread the sand on the board, add the cement, and mix these thoroughly. Add one-half of the required amount of water, spread the gravel or stone on top of this mixture, and mix thoroughly and add water to the dry spots until the mass is uniform and of the consistency of jelly. A very rough estimate of the quantity of water to use is 4 to 5 gallons for each sack of cement.

Thorough mixing is very essential. The cement should completely coat all particles of the stone and sand. A medium mixture, one that is between wet and dry, is recommended for general use.

One part of cement, three parts of sand, and five parts of stone or gravel make a good plain concrete mixture. One part of cement, two and one-half parts of sand, and five parts of stone or gravel may also be used. These parts are by measure, and a sack of cement contains approximately 1 cubic foot. A one-half inch coating of one part of cement and two parts of sand is usually put on to give a smooth finish to the floor, and should be put on before the base has set. This surfacing material is mixed to the consistency of mortar for laying brick. A moderately smooth surface can be made by working the ordinary concrete smooth with a straight-edged board.

Wooden floors, in most parts of this country, are usually made of one thickness of matched flooring. In the extreme northern sections, they are generally doubled to make them tight and warm, in which case the lower layer of boards is usually laid diagonally with building paper between the floors.

WALLS

The walls of most poultry houses are built of siding or flooring nailed directly to the studs. In the North, siding is usually placed over sheathing, making a wall of two thicknesses of boards, with building paper between; or roofing paper may be nailed on the sheathing. Boards 10 to 12 inches in width, placed vertically, with the cracks covered with battens 2 to 3 inches wide, make a cheap, tight wall. Battens are usually 1 inch thick, and may be either nailed or screwed to the house. They should be nailed to the framework to keep the sheathing from splitting. Matched lumber 1 inch thick is used extensively in poultry-house construction, and makes a very satisfactory wall, without any other covering. Narrow lumber, 2½ to 6 inches wide, is usually used for this purpose, as wide boards are apt to shrink so much as to leave cracks.

The lowest board on the walls should extend far enough over the sill to cover the joint. A tight joint should also be made at the eaves, either by cutting the rafters off even with the rear wall and covering this joint with good roofing paper, or by filling in the space between the rafters with boards. A wide board may be used as the first board on the rafters, allowing it to project from 2 to 4 inches beyond the rear wall, to protect the rear wall of the house. Sheathing should be laid so as to break joints in order to strengthen the building. Siding is usually laid from the bottom upward, and also with joints broken. A shutter may be placed just under the eaves on either the outside or the inside of the rear wall for summer ventilation (see figs. 4 and 13). The essential point is to have a rear wall which is tight near the roosts, to prevent drafts from striking the birds.

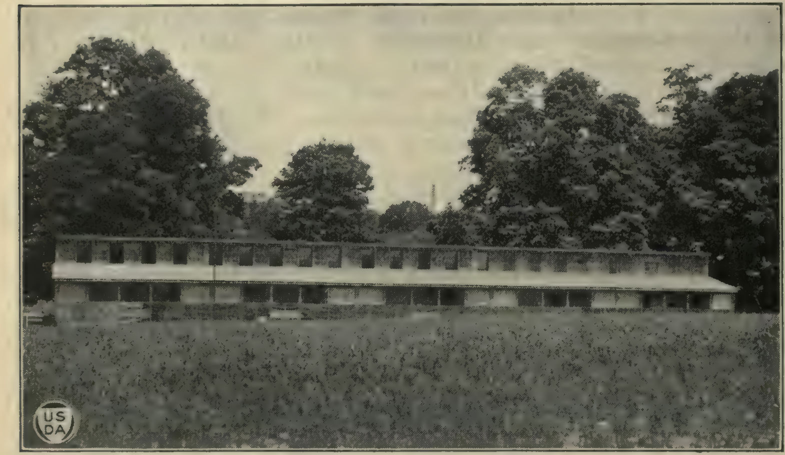


FIG. 9.—A semimonitor style of laying house. This type of roof allows the sun to shine well back into the house, but is more difficult to construct than a single-slope roof. The windows in the upper part of the front make it easy to ventilate and make a cool house in the summer. Care must be used in regulating these windows to prevent drafts in cool weather

ROOF

Prepared roofing, laid on wide matched sheathing, is ordinarily used for covering the roof. Wooden shingles are used in only a few sections of the country, principally on the Pacific coast. One or two-ply roofing material is usually used on the sides, and one, two, and three-ply roofing on the roof, although this varies with different styles and grades of manufacture. This prepared roofing may be had in the form of shingles or in rolls, containing directions and materials for laying. The sheathing should be planed on one side and laid close together to present a smooth surface for the prepared roofing. Sheathing paper is sometimes used between the sheathing and the roofing material. Prepared roofing may be used on roofs which have a slope of 1 or more inches to the foot.

Such roofing will last longer on a roof which has considerable slope than on a roof which has only a slight slope. A shed roof is the easiest one to cover with prepared roofing, which lasts especially well on this type of roof because it has a northern exposure and is not so much affected by the sun. The best way to fasten the loose ends of roofing paper is to bend them under the sheathing, fastening the paper with a narrow wooden board. (See fig. 16.)

Figure 9 shows a semimonitor type of roof on which prepared roofing is used, but this is a more difficult type to construct than the shed roof, because the junction of the lower front roof with the vertical face of the monitor must be constructed so as to make it weather tight. The roofing at this joint should extend 4 inches under the wall or window sill and turn up inside.

Wooden shingles may be laid from 4 to 5 inches to the weather, on roofs which have at least a one-third pitch, which is a rise of 8 inches to the foot, or a total height equal to one-third of the span of a gable roof or two-thirds of the span of a shed roof. Cedar and cypress shingles are usually laid not more than 5 inches to the weather on walls, and are not generally used on roofs which have a rise of less than 8 inches to the foot. Four bundles of wooden shingles are the equivalent of 1,000 shingles 4 inches wide, and estimates are made on this basis. The actual number of shingles may be more or less than 1,000, depending on the width, as shingles vary greatly in width, running all the way from 3 to 10 inches. One thousand shingles laid 4½ inches to the weather will cover about 125 square feet, depending on their size.

In shingling, commence at the eaves or lowest edge by laying a double course. The rest of the layers are single courses. They are laid either to a chalk line, which is made by fastening a chalked cord at the right points at either edge of the roof and snapping it to make a mark for the lower edge of the row of shingles, or to a straight-edged stick. Each shingle is nailed with two nails (4 penny), driven 7 to 8 inches from the butt, depending on the lap, so that the heads of the nails will be covered by the next course. It is advisable to use cement-coated, galvanized, or other rust-resistant nails. Shingles should be laid on narrow sheathing 3 to 5 inches wide, or on common sheathing, and should break joints at least 1 inch and as much more as possible. The sheathing boards should be spaced about 3 inches apart to allow the roof to dry out quickly.

ESTIMATING MATERIALS REQUIRED

Lumber comes in even lengths, usually 10, 12, 14, and 16 feet long. It is figured at so much per 1,000 feet board measure (b. m.), which means the number of square feet which the material would cover if it were 1 inch thick. The number of feet, board measure, in dressed lumber is based on the size of the lumber before it is dressed. The width of matched flooring is usually based on the width of the board before it is dressed and before the tongue and groove have been made. To compute board measure, multiply the width in inches by the thickness in inches, and multiply this by the length in feet, and then divide this result by 12. The accompanying table shows the number of feet, board measure, in lumber from 6 to 16 feet long, with a cross section varying from 4 to 16 square inches.

Table of board measure

Length	Area of cross section					
	4 inches	6 inches	8 inches	10 inches	12 inches	16 inches
	Board measure					
Feet	*Ft. in.*	*Feet*	*Ft. in.*	*Ft. in.*	*Feet*	*Ft. in.*
6	2 0	3	4 0	5 0	6	8 0
8	2 8	4	5 4	6 8	8	10 8
10	3 4	5	6 8	8 5	10	13 4
12	4 0	6	8 0	10 0	12	16 0
14	4 8	7	9 4	11 8	14	18 8
16	5 4	8	10 8	13 4	16	21 4

Boards less than 1 inch thick are usually sold by the board foot, the price depending on the thickness of the lumber. In estimating lumber, an allowance should be made for waste, adding one-tenth for common sheathing, one-fifth for matched lumber 6 inches wide, one-fourth for matched siding or lumber 4 inches wide, and one-third for matched flooring 3¼ inches wide.

A working plan of the building should be drawn to a convenient scale, usually one-fourth inch to the foot for poultry houses, showing the ground plan, the front elevation, and the end or a cross section of the house. The bill of materials can be worked from the plan.

Wire nails are generally preferred in construction, as they are easier to use than cut nails, although the latter have greater holding power. Use 10 to 20 penny nails for framing, 8 to 10 penny for sheathing, 8-penny for siding, and 6-penny finish or casing nails for clapboarding. Four-penny nails are 1½ inches long, 6-penny are 2. 8-penny are 2½, 10-penny are 3, and 20-penny are 4 inches long. It takes about 5 pounds of 4-penny nails to 1,000 shingles; 18 pounds of 6-penny for 1,000 square feet of beveled siding; 20 pounds of 8-penny and 25 pounds of 10-penny for 1,000 square feet of sheathing; 30 pounds of 8-penny for 1,000 square feet of flooring; and 15 pounds of 10-penny and 5 pounds of 20-penny for the studding in 1,000 square feet of frame wall.

A cubic yard of 1:3:5 concrete will take 4.64 sacks of cement, 0.52 cubic yard of sand, and 0.86 cubic yard of gravel. A cubic yard of 1:2 mortar surface will take 13.48 sacks of cement and 1 cubic yard of sand. One hundred square feet of a 3-inch concrete floor made of a 1:3:5 mixture will take 4.5 sacks of cement, 0.5 cubic yard of sand, and 0.83 cubic yard of gravel. A similar half-inch area of surface mortar of a 1:2 mixture will take 2.12 sacks of cement and 0.15 cubic yard of sand. A concrete wall can be made entirely of rough concrete, making the wall 6 inches wide and at least 2½ feet high, the top of the wall being level with the top of the floor. The bottom of the wall should go below frost depth.

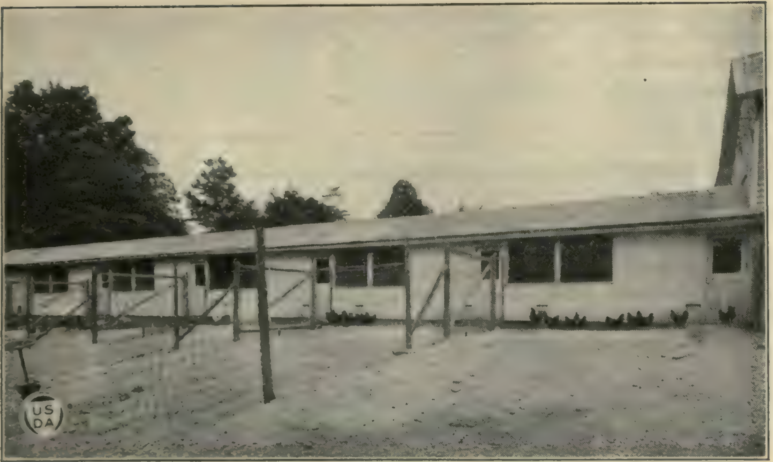


FIG. 10.—Laying house used at U. S. Experiment Farm, Beltsville, Md. Capacity, 500 hens. Plans shown in figs. 11, 12, and 13

PAINT AND WHITEWASH

Painting adds greatly to both the appearance and durability of all buildings and appliances. All surfaces should be clean and dry before they are painted. Use a priming coat made of about equal parts of paint and linseed oil and cover with one or more coats of paint, which should be thoroughly brushed into the wood.

Whitewash is cheap and may be used both inside and out. It is made by slaking quicklime in water. The lime should be placed in a vessel and water poured over it, covering the vessel with cloth or

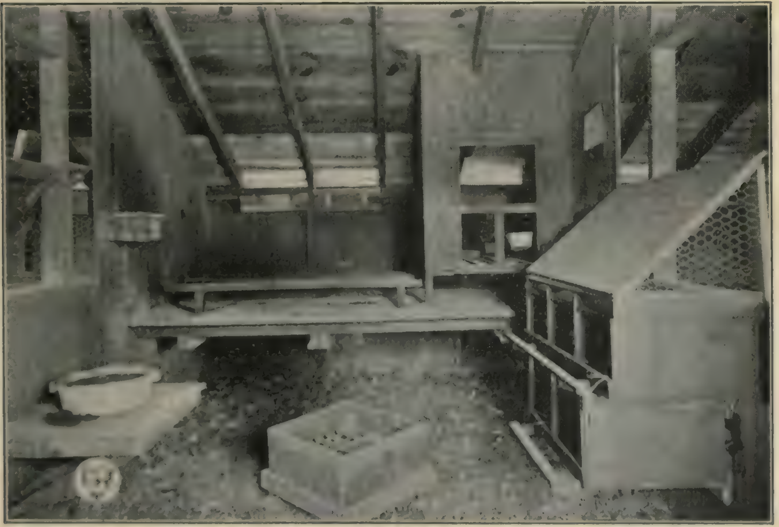


FIG. 11.—Interior of pen in laying house used at U. S. Experiment Farm, showing roosts, dropping board, and broody coop in the rear of pen and nests on the right partition. A dry-mash hopper is shown in the center of the pen and a water pan on the left partition. (See Fig. 10 for exterior view.)

burlap, and allowing the lime to slake for one hour. Water is then added to bring the whitewash to a consistency which may be applied readily. Whitewash is spread lightly over the surface with a broad brush, or may be put on with a spray pump.

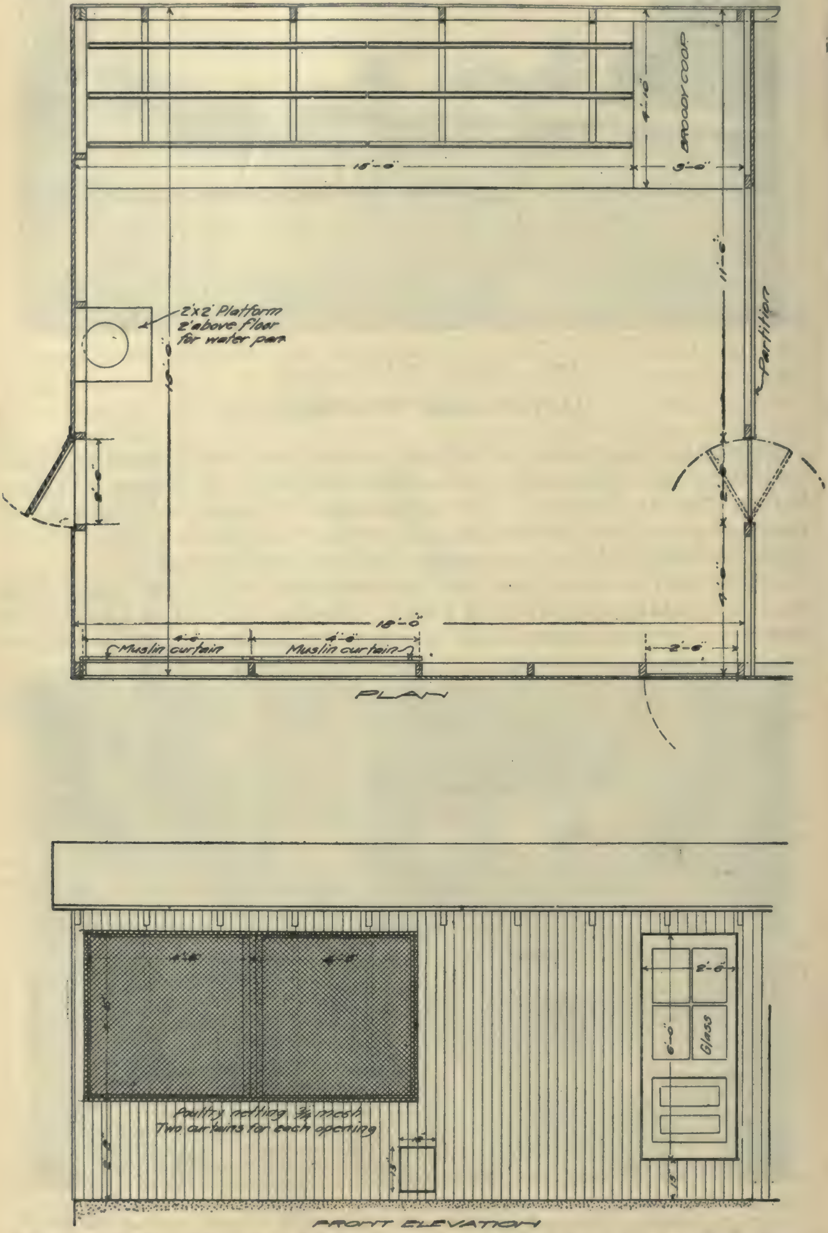


Fig. 12.—Portion of floor plan and front elevation of laying house used at U. S. Experiment Farm, Beltsville, Md. Capacity, 500 hens.

Interior whitewash may be made in the following manner: (1) Slake 1 bushel of quicklime with 15 gallons of water; (2) beat 2½ pounds of rye flour in ½ gallon of cold water and then add 2 gallons of boiling water; (3) dissolve 2½ pounds of common rock salt in 2½ gallons of hot water; mix 2 and 3, then pour into 1, and stir until thoroughly mixed.

A weatherproof whitewash for exterior surfaces may be made as follows: (1) Slake 1 bushel of quicklime with 12 gallons of hot water; (2) dissolve 2 pounds of common salt and 1 pound of sulphate of zinc in 2 gallons of boiling water; pour 2 into 1, then add 2 gallons of skim milk, and mix thoroughly.

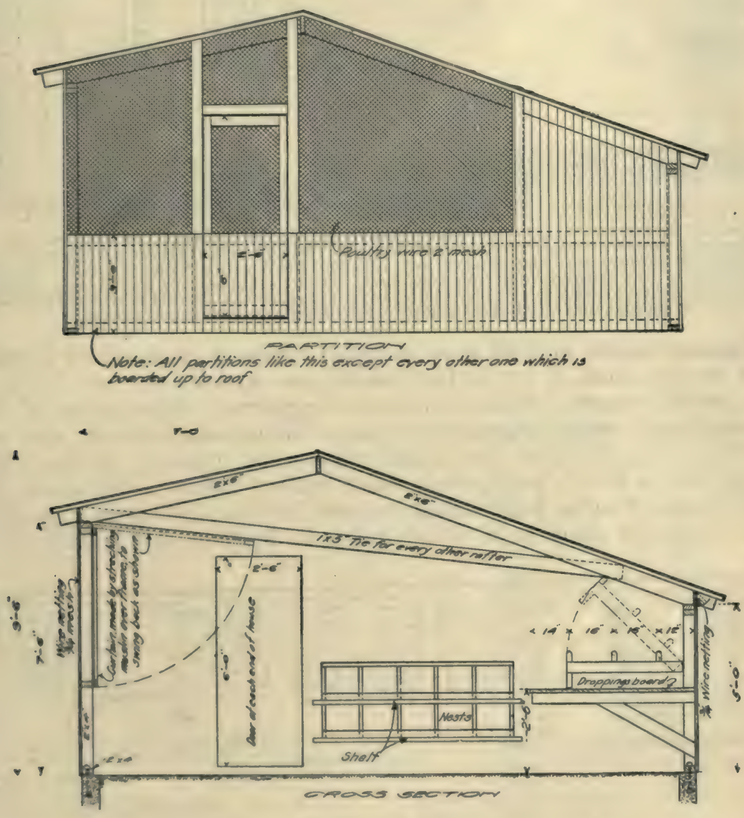

Poultry wire 2" mesh
2'-6"
PARTITION
Note: All partitions like this except every other one which is boarded up to roof
7'-0"
2"x6"
2"x6"
1"x3" Tie for every other rafter
2'-6"
Wire netting 1" mesh
Curtain made by stretching muslin over frame; to swing back as shown
3'-6"
7'-6"
6'-0"
Door at each end of house
2"x4"
2"x4"
< 14" × 16" × 16" × 12" ×
Droppings board
Wire netting
5'-0"
Nests
2'-0"
Shelf
CROSS SECTION

FIG. 13.—Partition and cross section of laying house used at U. S. Experiment Farm at Beltsville, Md. Floor may be of concrete or earth, but the former is better. Capacity, 500 hens. (See Fig. 12.)

PLANS AND BILLS OF MATERIALS

Figure 10 shows a long laying house, capacity, 500 hens, in use at the United States Experiment Farm, Beltsville, Md. This house is equipped with trap nests, which are illustrated in Figure 11. Figures 12 and 13 show the details of this house. It has a combination type of roof. The bill of materials, including a concrete floor and foundation walls, is as follows:

Bill of materials for laying house 18 by 108 feet

Lumber	Size	Number of pieces	Length	Board measure
	Inches		*Feet*	*Feet*
Sills	2 by 4	30	12	240
Plates	[1] 2 by 4	44	12	352
Ties for rafters	1 by 5	30	16	220
Rafters	2 by 6	56	14	784
Do	2 by 6	56	10	560
Studs	2 by 4	38	12	304
Studs (front)	2 by 4	28	8	150
Roosts	2 by 3	36	8	144
Total				2,754

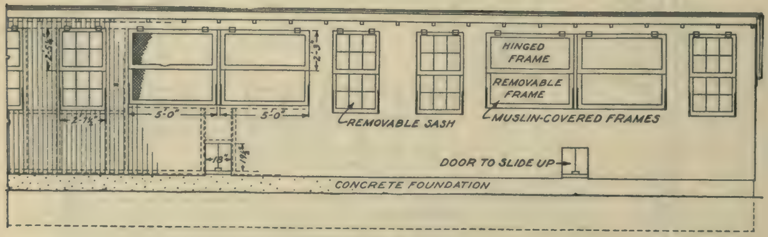
	Feet
Sheathing surfaced one side for roof	2,860
Matched flooring for walls, partitions, and dropping board	3,200
Boards planed both sides for nests	300

[1] Doubled

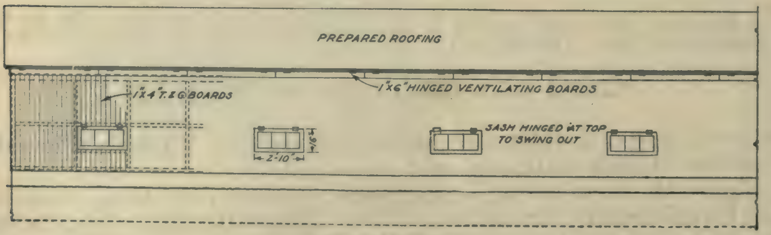
186 bags of cement, 43.5 cubic yards of unsifted gravel, and 33 cubic feet of sand, for floor and walls.

340 running feet of 1 by 3 inch furring for curtain frames. 300 square feet of ¾-inch mesh wire for front. 300 square feet of 2-inch mesh wire for partitions. 350 square feet of muslin cloth for curtains. Prepared roofing paper to cover 2,700 square feet. 8 outside doors. Hardware (hinges, nails, staples, etc.). Concrete wall or posts (either concrete or wood) for foundation. If posts are used, the sill should be 4 by 4 inches instead of 2 by 4 inches, thus doubling the number of feet (board measure) required for sills.

Figures 14, 15, and 16 show detailed plans of one-half of a shed-roof laying house 20 by 80 feet, which has capacity for 400 fowls of the general-purpose type, or for 500 Leghorns. This is one of the simplest and most inexpensive types of house to construct, and one of the most practical for large commercial poultry farms. The depth makes this a very comfortable winter house. The house can be made any length, long enough to hold 1,000 to 1,200 hens if desired, but this is as many as it is advisable to keep in one house. This



FRONT ELEVATION


PREPARED ROOFING
1"x4" T.&G. BOARDS
1"x6" HINGED VENTILATING BOARDS
SASH HINGED AT TOP TO SWING OUT
2'-10"

REAR ELEVATION

FIG. 14.—Front and rear elevation of shed-roof laying house, 20 by 80 feet, capacity 400 to 500 hens. (See figs. 15 and 16.) Bill of materials shown on page 23.

house is divided into pens 20 by 40 feet each, the partitions serving to keep the hens in smaller flocks and also helping to prevent drafts.

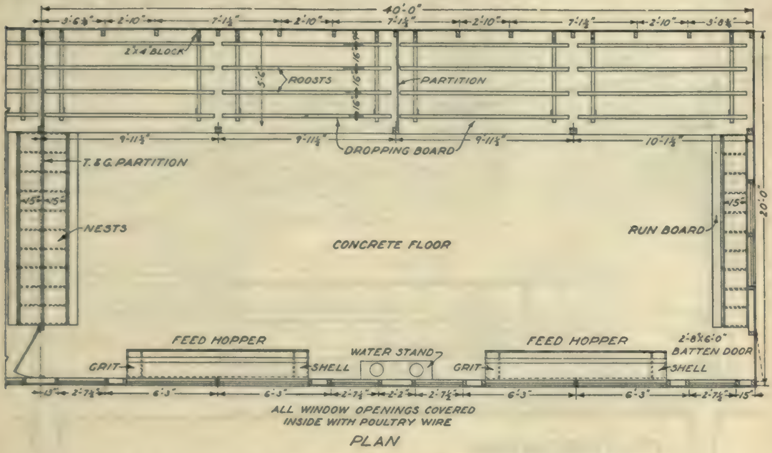


FIG. 15.—Plan of shed-roof laying house shown in Figure 14. This house is 20 feet wide and can be built any length desired

Bill of materials for shed-roof house, 20 by 80 feet, as shown in Figures 14, 15, and 16.

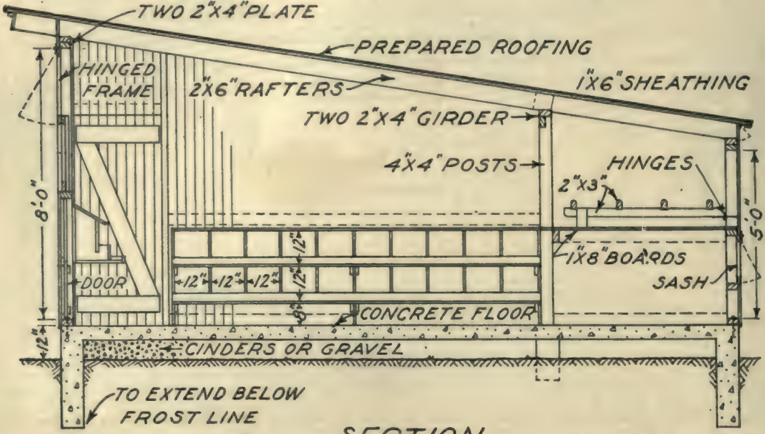
Lumber	Size	Number of pieces	Length	Board measure
Framing:	*Inches*		*Feet*	*Feet*
Sills	2 by 4	24	10	160
Rear studs	2 by 4	14	10	93
Front studs	2 by 4	32	8	171
End studs	2 by 4	6	12	48
Posts	4 by 4	4	12	64
Purlins	2 by 4	16	10	107
Plates	2 by 4	32	10	213
Rafters	2 by 6	44	16	704
Rafters	2 by 6	22	12	264
Horizontals	2 by 4	24	10	160
Dropping board	2 by 4	8	10	53
Studs, partition	2 by 4	3	8	16
Horizontals, partition	2 by 4	2	10	13
			Lin. ft.	
Roosts	2 by 3		400	200
Vent board, surfaced, four sides	1 by 6		80	40
Eave strip	1 by 2		186	31
Fascia on rafters	1 by 6		82	41
Frame for curtain	1 by 3		240	60
Tongue-and-groove roof sheathing	1 by 6			2,000
Tongue-and-groove flooring (covering)	1 by 4			1,400
Tongue-and-groove flooring (dropping board and small partitions)	1 by 4			650
12-inch boards, surfaced four sides, for nests, etc				650
Tongue-and-groove flooring (partitions)	1 by 4			375
Total feet board measure				7,513

304 square feet 2-inch mesh poultry wire.
160 square feet muslin for frames.
Roof covering for 1,800 square feet area.
12 cellar sash, 3 lights, 10 by 12 inch glass.
16 sash, 6-light, 10 by 12 inch glass.
29 pairs 2-inch galvanized butts for cellar sash and vents.
16 pairs 2½-inch galvanized butts for other sash and frames.
3 pairs 5-inch T hinges for doors.
20 ½-inch diameter foundation bolts 16 inches long, with nuts.

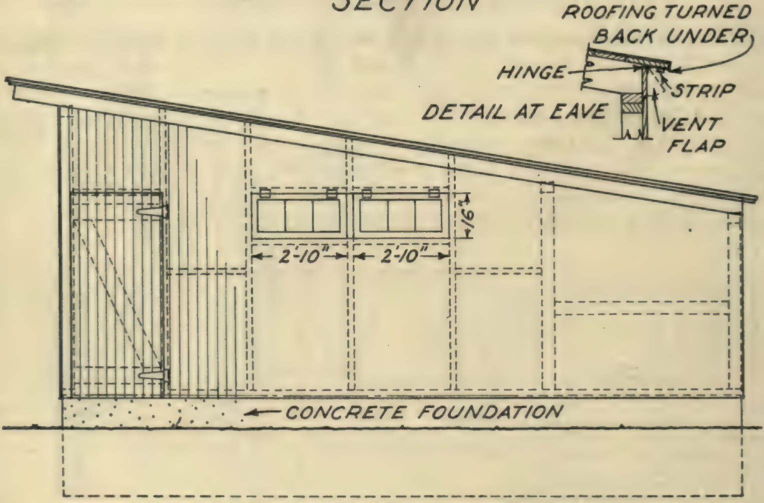
Concrete: Foundation, 70 sacks Portland cement, 7.6 cubic yards sand, 12.6 cubic yards gravel; floor, 96 sacks Portland cement, 10.4 cubic yards sand, 17.2 cubic yards gravel.

Nails, paint, etc., as required.

The yard for commercial laying flocks should be the full length of the house, and about 125 feet deep, one such yard in front and one in the rear of the house. No partitions are necessary in the yards for laying flocks, as the hens will distribute themselves through the pens, even though all are allowed to run in one yard. Hens will tend to congregate at the end of the house where feeding is begun, so it is desirable to begin feeding at opposite ends of the house on alternate days to keep the hens more evenly distributed throughout the house.



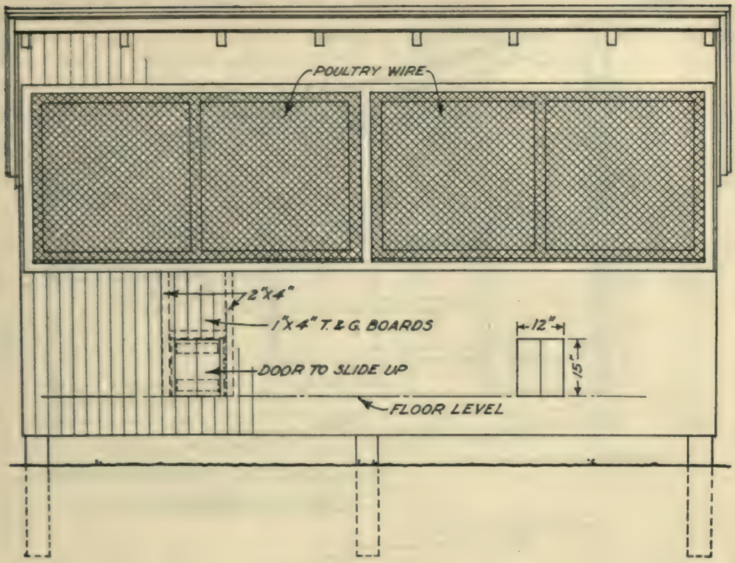
SECTION



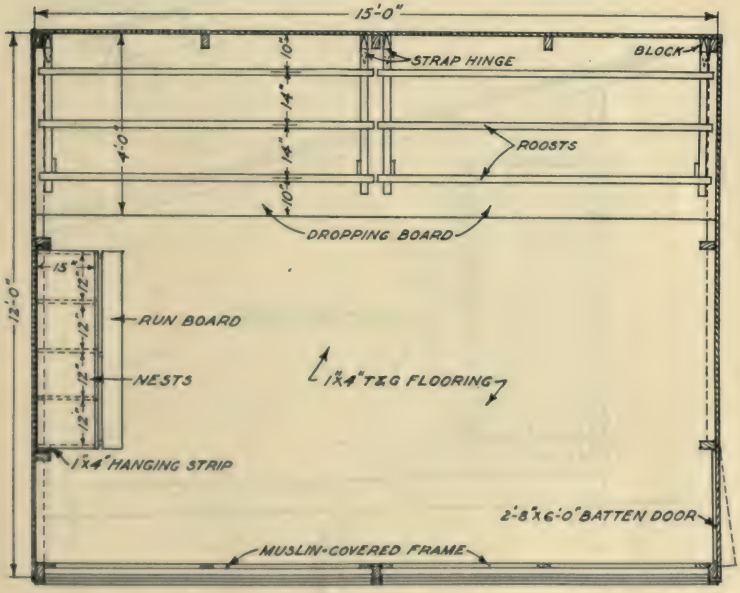
END ELEVATION

FIG. 16.—Section and end elevation of large shed-roof laying house shown in Figures 14 and 15

Figures 17 and 18 show detailed plans of a simple type of shed-roof laying house, 12 by 15 feet in size, with capacity for 60 hens.

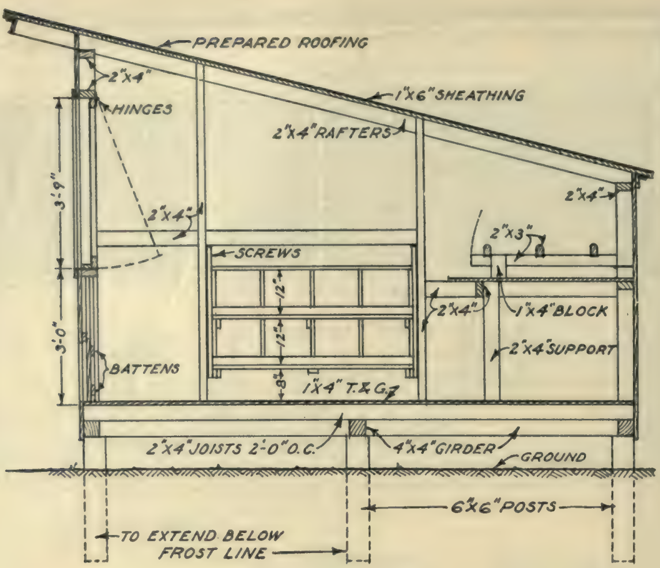


FRONT ELEVATION

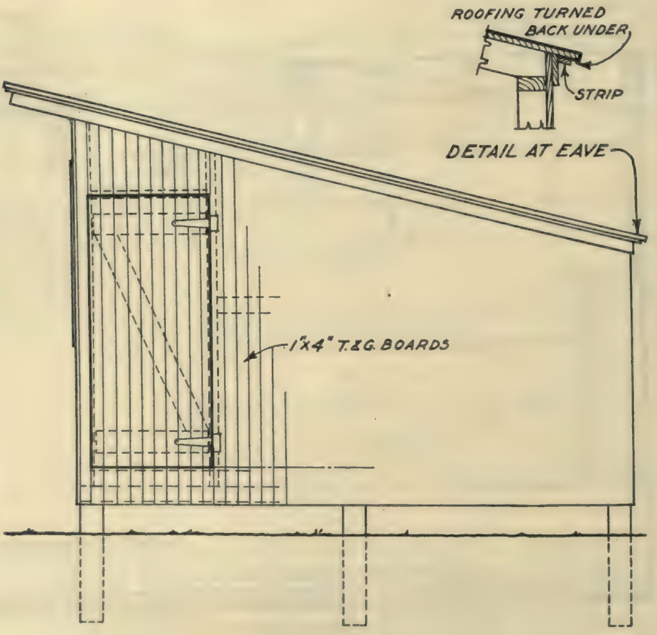


PLAN

FIG. 17.—Front elevation and plan of simple shed-roof laying house for 60 hens, adapted for a general farm or a large back-yard flock. (See fig. 8.) Bill of materials shown on page 27



SECTION



END ELEVATION

FIG. 18.—Section and end elevation of laying house for 60 hens. If used in the North, reduce curtain space and insert one good-sized window

A house of this general type is illustrated in Figure 8. This house is boarded up and down, and only a small amount of framing material is used. The bill of materials follows:

Bill of materials for laying house for 60 hens, as shown in Figures 17 and 18

Lumber	Size	Number of pieces	Length	Board measure
Framing:	*Inches*		*Feet*	*Feet*
Girders	4 by 4	3	16	64
Do	4 by 4	2	12	32
Floor joists	2 by 4	9	12	72
Studs and horizontal bridging	2 by 4	7	10	47
Do	2 by 4	11	8	59
Roof rafters	2 by 4	8	14	75
Plates	2 by 4	2	12	16
Dropping board	2 by 4	1	16	11
Roosts	2 by 3	4	14	28
Nests, smooth surfaced four sides	1 by 12	3	12	36
			Lin. ft.	
Trim, surfaced four sides	1 by 6		60	30
Under roof	1 by 2		104	18
Canvas frames, surfaced four sides	1 by 3		60	15
Tongue-and-groove sheathing	1 by 6			220
Tongue-and-groove flooring, sides, and dropping board	1 by 4			600
9 posts, 6-inch diameter, 2 feet 6 inches long; may be of locust, cedar, creosoted wood, tile filled with concrete, or concrete blocks				
Total feet board measure				1,323

16 linear feet 2-inch mesh galvanized poultry wire 4 feet wide.
60 square feet muslin cloth for frames.
Prepared roofing for 224 square feet area.
Hinges, fasteners, nails, paint, etc.
Battens, etc., provided under sheathing.

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September 11, 1924

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1414

The ROSETTE DISEASE OF WHEAT AND ITS CONTROL

THE ROSETTE DISEASE OF WHEAT was first discovered in the United States in Madison County, Ill., in April, 1919. It was subsequently found in other parts of Illinois and in Indiana.

Where conditions for the disease are favorable, the rosette disease may ruin the affected crop. Usually, however, the disease occurs in more or less irregular, scattered spots of different sizes. In all except the most severely affected fields, the reduction in yield has been less than 20 per cent.

The rosette disease is recognized in the field in the spring by stunted and rosetted plants and by bunchy dying plants in the diseased spots. All plants affected with this disease produce tillers excessively and look bunchy. At first they are dull blue in color, but they subsequently turn brown and often die.

In the final stages of the disease, the plants show considerable rotting of the roots and a brown basal rot of the tillers underground.

In late spring this disease may be confused with Hessian fly injury. In both cases the color of the affected plants is about the same. The rosette disease, however, shows no symptoms in the fall, while the fly causes marked injury. Later, rosette-diseased plants may be distinguished by the much greater tendency to tiller.

The cause of the rosette disease has not yet been determined. It may be controlled by sowing resistant varieties.

Numerous varieties have been studied to determine their relative resistance to the disease. Red Wave, Early May, Shepherd, and Turkey are particularly immune. Fultz and Fulcaster are highly resistant. Harvest Queen, known locally as Salzer's Prizetaker and Red Cross, is almost completely susceptible.

Washington, D. C. Issued June, 1924

THE ROSETTE DISEASE OF WHEAT AND ITS CONTROL.[1]

By AARON G. JOHNSON, *Pathologist*, HAROLD H. MCKINNEY, *Pathologist*, ROBERT W. WEBB, *Assistant Pathologist*, and CLYDE E. LEIGHTY, *Agronomist*, *Office of Cereal Investigations, Bureau of Plant Industry.*

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DISCOVERY OF THE ROSETTE DISEASE.

THE PRESENCE of the rosette disease in winter wheat was discovered about the middle of April, 1919, through a report from the county agent of Madison County, Ill., that wheat near Granite City was being severely injured by some disease. Later, this disease was found in other parts of Illinois and in Indiana.

Shortly after the discovery of this trouble the name "take-all" was applied to it, tentatively, on account of certain points in which it resembled the Australian take-all of wheat. Extensive field and laboratory investigations have shown that it is distinctly different from Australian take-all, and the name "rosette disease" has been applied to the disease occurring in Illinois and Indiana.

ECONOMIC IMPORTANCE OF WHEAT ROSETTE.

Under conditions favorable for its development the rosette disease may cause considerable damage. In the spring of 1919 some of the wheat fields in Madison County, Ill., were so badly affected that they were plowed up and planted to other crops. In one case a 40 per cent actual reduction was caused in the total yield of grain in a 50-acre field in that county. In several cases observed the reduction in yield has been about 20 per cent; the loss in most cases up to this time has been much less.

Under conditions favorable for the wheat crop, the diseased plants may send up secondary tillers which form a thin to fairly thick stand

---

[1] All the field experiments for the control of the rosette disease have been conducted on fields in the "American bottoms" of the Mississippi River near Granite City, Ill., in cooperation with the Illinois Agricultural Experiment Station, and at Wanatah, Ind., in cooperation with the Indiana Agricultural Experiment Station. Certain laboratory and greenhouse studies have been conducted in cooperation with the department of plant pathology at the Wisconsin Agricultural Experiment Station. In 1919 the field-laboratory studies were conducted in the laboratories of the Missouri Botanical Garden, St. Louis, Mo., through the kindness of Director George T. Moore and Dr. B. M. Duggar. In 1920 the field-laboratory studies were made in the laboratories of the Granite City, Ill., high school, through the courtesy of Superintendent L. P. Frohardt.

and produce some grain. These tillers mature later than plants that have not been affected by the disease and usually produce only shrunken grain. In badly infested fields this unevenness in ripening may make it advisable to postpone harvesting until the healthy grain is overripe, or, if possible, to divide the field and harvest the diseased area at a later date. Losses due to shattering of overripe grain and the lower yields and poorer quality of grain produced on infested land must be taken into consideration in deciding the date of harvest.

GEOGRAPHIC DISTRIBUTION.

So far as known the rosette disease occurs only in Illinois and Indiana. There is a possibility that it may be present in Colorado, but this has not been determined with certainty.

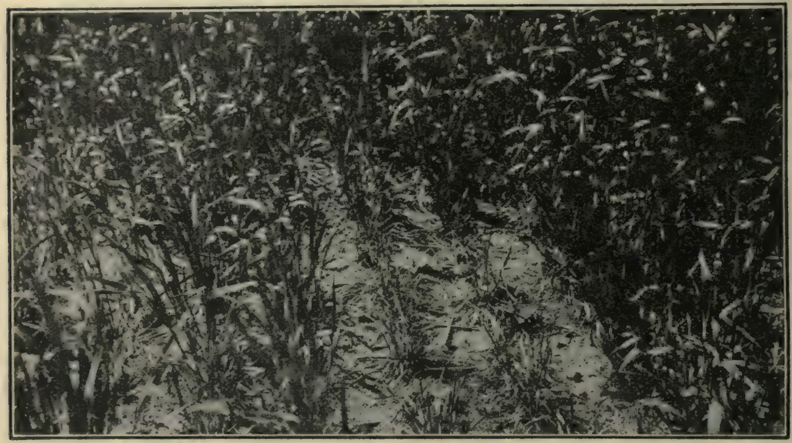

FIG. 1.—Portion of a spot in a wheat field infested with rosette.

The true Australian take-all has been found in Arkansas, California, Indiana, Kansas, Maryland, New York, North Carolina, Oregon, Tennessee, and Virginia, and a disease which is very similar to it, if not identical with it, has been found in Washington.

CROPS AFFECTED.

Investigations conducted thus far have not shown positively that any crop other than wheat is susceptible to the rosette disease. There are some indications that rye may be very slightly susceptible.

SYMPTOMS OF WHEAT ROSETTE.

SYMPTOMS IN THE SPRING.

The conspicuous symptoms of the rosette disease first become evident in the spring after growth of the healthy plants is well started. Distinct patches of badly dwarfed plants are found here and there in some fields without regard to the type or condition of the soil (fig. 1). Some of these patches may be so small as to include only a comparatively few diseased plants. In fact, the diseased plants sometimes may occur one in a place, here and there, intermixed with apparently healthy plants. In such cases these diseased plants are difficult to find, and hence are commonly overlooked. Definite spots containing diseased plants usually can be recognized. The edge of such a spot generally is more sharply defined than the margins of spots caused by unfavorable soil conditions, especially poor drainage. In such spots most of the plants are diseased and therefore stunted right up to the edge of the spot (fig. 2, *B*). In spots caused by local unfavorable soil conditions all the plants usually decrease in height rather gradually from the edge toward the center (fig. 2, *A*).

In fields more severely infested, the patches may be very large and contain a high percentage of diseased plants, or they may cover even large portions of the infested fields.

Wherever found, the diseased plants in the spring show certain distinct characteristics, particularly (1) dwarfing, and a little later (2) abnormal dark-green coloration of the fall leaves, (3) dying of outer leaves and fall tillers, (4) usually a browning of the bases of affected plants (fig. 3), (5) excessive development of spring tillers, and (6) some plants may be killed entirely.

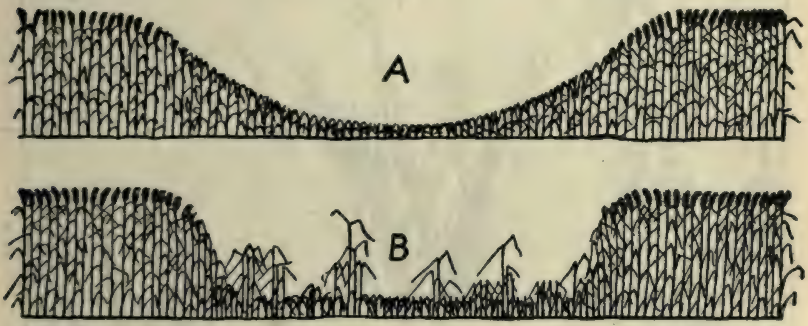

FIG. 2.—Diagram of a section of a spot caused by local abnormal soil conditions (*A*) and a spot caused by the rosette disease (*B*).

Early in the spring, if healthy and diseased plants growing side by side are pulled up, it will be noted that the disease is fairly well limited to individual plants which at that time show marked dwarfing but no basal browning of the living tissues. A little later the diseased plants show a browning and still later a rotting of the basal portions, that is, those parts just below the surface of the ground. The roots may not show any particular evidence of disease, or they may show some discoloration when the basal browning occurs. The diseased plants may be immediately adjacent to and intermixed with healthy plants. Along with the development of the basal browning and rotting, spring tillers become evident in excessive numbers, giving the diseased plants a bunchy appearance (fig. 4). Under certain soil conditions, especially when the soil is dry, some of the diseased plants die in the spring while still in the dwarfed stage.

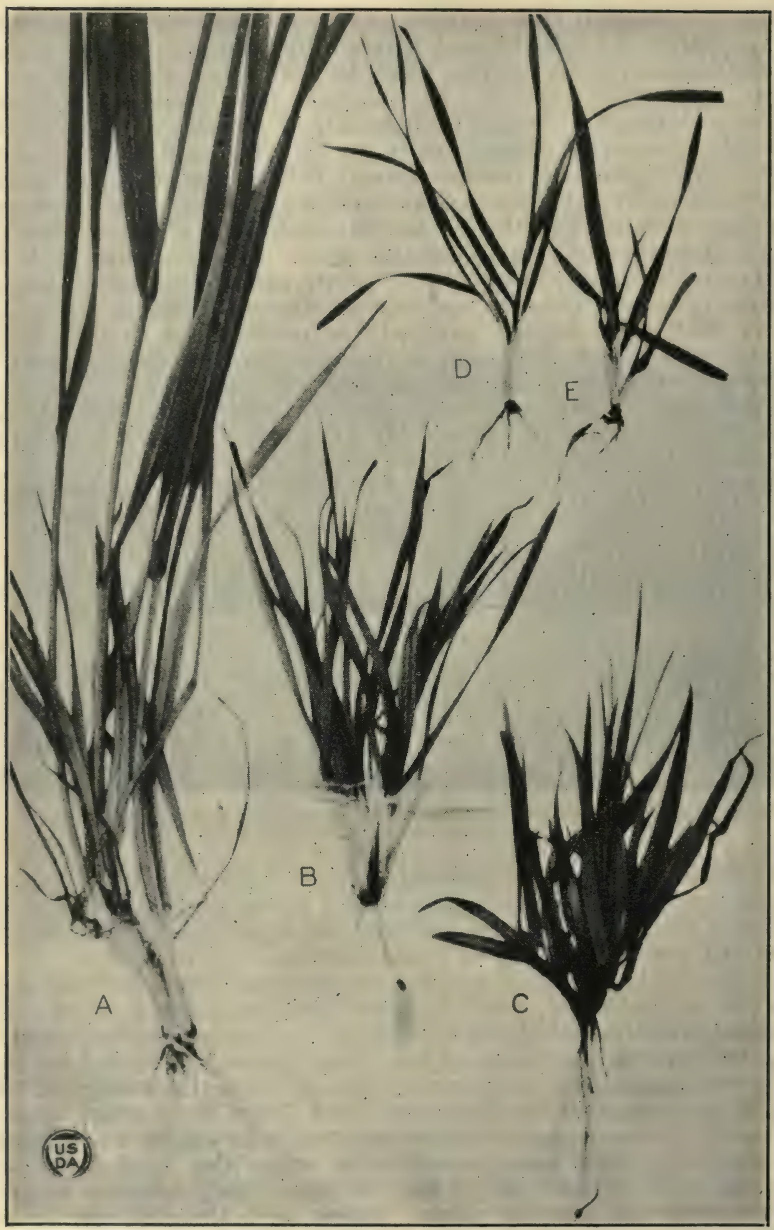

FIG. 3.—Healthy winter-wheat plants and those showing the effects of rosette and Hessian fly, respectively: *A*, Healthy plant in the spring; *B* and *C*, plants of the same variety and age as in *A*, showing early and advanced stages, respectively, of the rosette, both having a bluish green color; *D*, healthy plant in late autumn; *E*, plant of the same age as *D*, infested by the Hessian fly, with the same bluish green leaf color as in *B* and *C*. (After a colored plate by McKinney and Larrimer in U. S. Dept. Agr. Bul. 1137.)

SYMPTOMS LATER IN THE SEASON.

When the healthy wheat plants are beginning to head, or the heads are in the boot, the diseased plants usually show partial recovery (fig. 5) and send up one or more short, weak stems. In some cases, where soil conditions are very favorable, rather complete recovery may occur, so that the infested areas may be difficult to locate by the time the crop is mature.

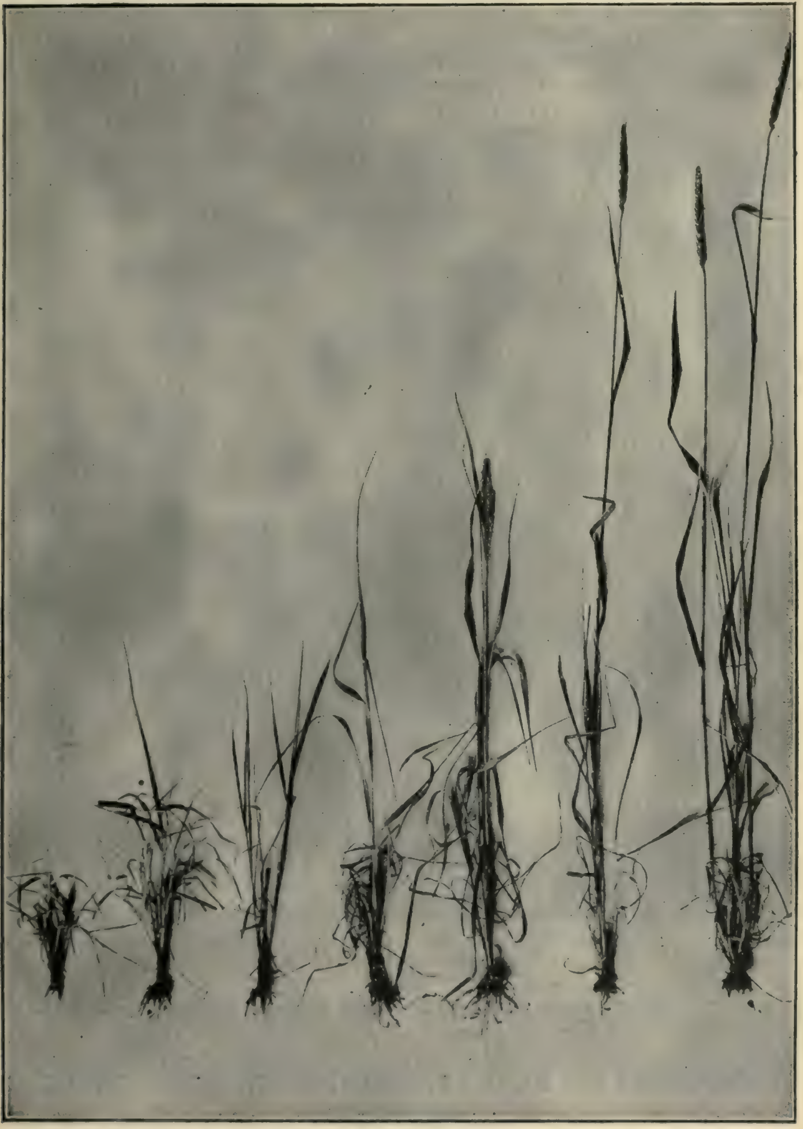

FIG. 4.—Wheat plants at the flowering stage, showing all stages of rosette injury. A healthy plant on the right.

When healthy plants are ripening, the diseased plants are still green. On account of this, the infested areas show conspicuously as green spots in the ripening healthy grain. Frequently, especially in wet seasons, the development of weeds in the infested areas adds to the general green effect brought about by the green condition of the diseased plants.

When the diseased plants recover sufficiently to develop heads, these are short and only imperfectly filled or not filled at all. This is in striking contrast with the large well-filled heads of healthy plants (fig. 5) at harvest time.

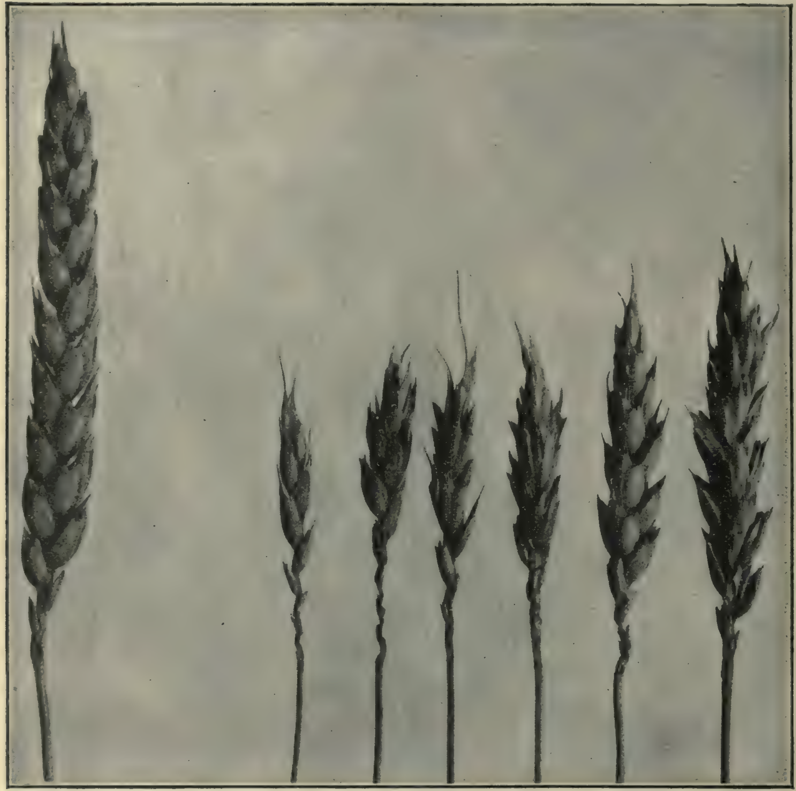

FIG. 5.—Head from a healthy wheat plant (left). Heads from plants partially recovered from rosette infection (right).

SYMPTOMS OF ROSETTE COMPARED WITH INSECT INJURIES.

At certain stages the symptoms of the wheat rosette disease somewhat resemble those caused by Hessian fly injury. In both cases the plants affected have a somewhat similar green color in the spring, different from the normal green of healthy plants. In the case of the rosette disease the color is a dark blue-green, practically identical in color with the dark green of plants infested with the Hessian fly (fig. 3). The rosette disease does not show any symptoms in the fall, while the Hessian fly causes very noticeable fall injury. Plants infected with the rosette disease show an excessive development of tillers, while plants injured by the Hessian fly generally do not tiller as much as normal plants.

In late spring there is a possibility of confusing the two maladies, especially if there is some spring infestation of the Hessian fly in plants affected by rosette. At this time bare areas may occur in fields where diseased plants have been washed out by heavy rains. Such fields usually can not be distinguished from those suffering from a severe attack of the fly, when the infestation of either is general over the field. Wheat rosette, however, usually occurs in spots, while spring fly infestation seldom, if ever, occurs in localized areas or spots in the field. The occurrence of such field spotting is practically conclusive evidence that fly injury is not the sole cause.

In fields where both rosette and fly are present, some of the diseased plants will show fly infestation, but usually many near-by plants affected by rosette will show no evidence of such infestation. In plants suffering only from fly injury the larva or flaxseed stage of the insect or the empty flaxseed cases will be found at the base of the plant, usually inside the first leaf sheath.

The wheat-stem maggot may infest wheat fields in the fall, presenting at that time very much the same appearance as that caused by Hessian fly. It is generally not so prevalent as the fly. The plants affected by the wheat-stem maggot usually die during the fall or winter and so will not lead to confusion with rosette in the spring. These dead and more or less rotted or decayed plants in the spring contain the full-grown larvæ or pupæ of the insect.

The wheat strawworm infests plants almost invariably only in the vicinity of old wheat stubble, which is not the case with rosette. Plants are infested by the strawworm only in the spring and develop symptoms that resemble Hessian fly injury. Injury by strawworm can be distinguished from rosette by means of the bulblike swelling at the base of the infested plants, and by the absence of the excessive tillering caused by rosette.

RECURRENCE.

In 1919, when the disease was first observed, it was thought by some that the trouble was caused by the exceptionally mild winter of 1918–19, and considerable doubt was expressed whether the disease would reappear in a normal season. At the present time, however, there can be no doubt on this point, as the disease has recurred each spring since its discovery in 1919. From present knowledge and past experience there is every reason to believe that the disease will recur every year when susceptible varieties of wheat are sown on infested land.

CAUSE.

The cause of the rosette disease of wheat has not yet been determined.

CONTROL OF WHEAT ROSETTE.

Various control measures for the disease have been tested, and important progress has been made. It is known that the soil carries the causal factor, whatever it may be. Attempts to control the disease on infested land by seed treatments therefore are useless. So far there is no indication that cropping methods, summer fallow, burning the diseased stubble, or the application to the infested soil of ground limestone, fertilizers, or such chemicals as iron sulphate will control the disease at all.

LATE SEEDING.

Wheat sown very late in the fall has not been affected by the rosette disease as much as wheat sown at the usual seeding time. Late seeding can not be recommended, however, as a means of controlling the disease, for late-sown wheat is liable to winterkill and give low yields.

RESISTANT VARIETIES.

Experiments conducted with a large number of varieties and strains of winter wheat show that the disease can be controlled by the use of resistant varieties. In these experiments seed of about 200 lots of wheat was sown in rows or plats on land in Illinois and Indiana that was known to be infested. The resulting plants were examined the following spring, and the percentage of infection in each lot was recorded.

The varieties tested in plats were sown in the fall of 1919 in adjacent parallel strips, one drill width (54 inches) wide and 50 rods long, on a uniformly infested and practically level field located near Granite City, Ill. The results of the plat trials are briefly summarized in Table 1. The varieties are listed in the same order in which they were sown in the plats.

TABLE 1.—*Resistance and susceptibility of certain varieties of wheat to rosette, as shown by plat experiments conducted near Granite City, Ill., in 1920.*

Variety of wheat.		Rosette in plats.	Yield per acre.	Weight per bushel.
Local name.	True name.			
		Per cent.	*Bushels.*	*Pounds.*
Salzer's Prizetaker	Harvest Queen	90	8.87	54.75
Red Wave	Red Wave	0	28.33	56.75
Illini Chief	Illini Chief	25 to 30	24.08	58.00
Harvest King	Harvest King	Trace	28.83	56.50
May	Early May	0	25.61	58.50
Red Cross	Harvest Queen	78	13.51	53.00
Fultz	Fultz	2	26.20	59.50
Winter Fife	Jones Fife	(1)	32.87	58.50
Turkey Red	Turkey	0	21.50	60.00
Fulcaster	Fulcaster	2	25.80	60.75

[1] Two plants.

The varieties and strains grown in rows were sown by hand in shallow furrows a rod long and 8 inches apart. Sowings of this sort were made in 1919, 1920, 1921, and 1922 at Granite City, Ill., and in 1921 and 1922 at Wanatah, Ind. Yields of these rows have not been determined. A few varieties showed a high degree of susceptibility. Harvest Queen is the only widely grown variety that has been found to be highly susceptible. Several other important wheats have shown a small percentage or a trace of infection. Harvest Queen was one of the important varieties being grown by farmers in 1919 in the area of Illinois in which the rosette disease was first found. It was there known as Salzer's Prizetaker. It is a soft red beardless wheat, with white glabrous (smooth) chaff and red kernels. The name Salzer's Prizetaker is incorrectly applied to this variety, inasmuch as the original Salzer's Prizetaker has brown chaff and white kernels. Fortunately Harvest Queen (Salzer's Prizetaker) has almost disappeared from the worst infested area, since farmers have seen how susceptible it is to the disease. This variety is sometimes also called Red Cross. Another variety, also known as Red Cross, has brown chaff and red kernels and is resistant, or only slightly susceptible, to the rosette disease.

Several well-known varieties showed from 1 to 5 per cent of infection. Among these are Fultz, Jones Fife (two lots), Illini Chief, and China (Pennsylvania Bluestem). One lot of Illini Chief showed 25 per cent infection in one case.

Many of the important wheats of the United States showed no rosette infection in these experiments. Five important classes, hard red spring, hard red winter, soft red winter, common white, and club, are represented. The varieties that were found resistant are used in sowing about one-eighth of the acreage of hard red spring wheat, nearly all of the acreage of hard red winter wheat, by far the larger part of the acreage of soft red winter wheat, about one-third of the acreage of common white wheat, and about one-fifth of the acreage of club wheat. It is possible, therefore, to find among the resistant varieties one or more suited to almost any part of the United States.

On account of the large number of immune or resistant varieties it is not difficult to control the rosette disease in farm practice. In central Illinois and northwestern Indiana where wheat rosette occurs the matter of control of the disease is comparatively simple. Numerous varieties immune from rosette and adapted to these sections are known. Principal among these are Turkey and other varieties of hard red winter wheat now widely grown in these two areas. Other important wheats, of the soft red winter type, immune from rosette are: Currell, certain lots of Fulcaster and Fultz, Fultzo-Mediterranean, Gipsy, Gladden, Jones Fife (two selections), Mammoth Red, Mediterranean, Michikoff, Poole, Harvest King, Portage, Red May, Early Ripe, Michigan Amber, Red Cross (red chaffed), Red Rock, Red Wave, Rudy, and Trumbull.

By sowing the hard red winter wheats of the Turkey type on infested land in areas where these are adapted and the soft red winter varieties named above in areas suited to them, it is almost certain that the rosette disease will be controlled.

CONTROL IN THE FLAG-SMUT AREA.

In southern Illinois, where flag smut of wheat (*Urocystis tritici*) occurs in the same locality with the rosette disease, additional care must be taken in choosing varieties for sowing. The varieties resistant to both diseases are rather few in number. Farmers have substituted Red Wave and Fultz, and to some extent hard red winter wheats of the Turkey type, for the varieties that have shown high susceptibility. Red Wave and Fultz, although immune from rosette, are somewhat susceptible to flag smut. The hard red winter wheats, while practically immune from both diseases, are not entirely satisfactory from the farmer's standpoint in the southern Illinois area. Climatic conditions there are not suitable for the best development of this type of wheat.

Two beardless strains developed from plant selections made several years ago and known as Early Harvest and Shepherd appear to be desirable varieties from the farmer's standpoint. They have been immune from both diseases, yield well, and produce a good quality of soft red grain. No commercial supply of seed is yet available, but Shepherd is being increased as rapidly as possible. A number of bearded wheats have been found immune from both rosette and flag smut. The most important of these two selections of Fulcaster (known as Eversole), Stoner (Marvelous), and Red Rock. Large stocks of seed of Stoner and Red Rock are available, but not all of the stocks of these varieties grown in this area have shown entire freedom from flag-smut infection. Possibly some of this small percentage of infection is due to slight mixtures of susceptible varieties, which are likely to be found in wheat as ordinarily grown by farmers.

A group of bearded wheats with glabrous (smooth) white chaff and purple straw, belonging to the soft red winter class, has shown immunity from, or high resistance to, both flag smut and rosette. Fulcaster is the leading variety in this group. Other names under which this type of wheat is known include Bearded Purplestraw, Dietz, Lancaster, Mammoth Red, Marvelous, and Stoner. This type of wheat is widely grown under one or another of its names in Missouri, Illinois, Indiana, and other States. Large stocks of practically pure seed are available, and it is probable that if they were used on infested land in the area growing soft red winter wheat until fully immune varieties are available, rosette and flag smut would do but little, if any, damage. Field tests with Fulcaster wheat have shown it to be one of the varieties best adapted to southern Illinois. It is also known to be one of the best soft red wheats in milling and baking qualities.

Additional data are given on varietal resistance of wheat to flag smut in University of Illinois Agricultural Experiment Station Bulletin No. 242 and in United States Department of Agriculture Circular 273. Additional data on the rosette disease also can be obtained from the United States Department of Agriculture, Washington, D. C.

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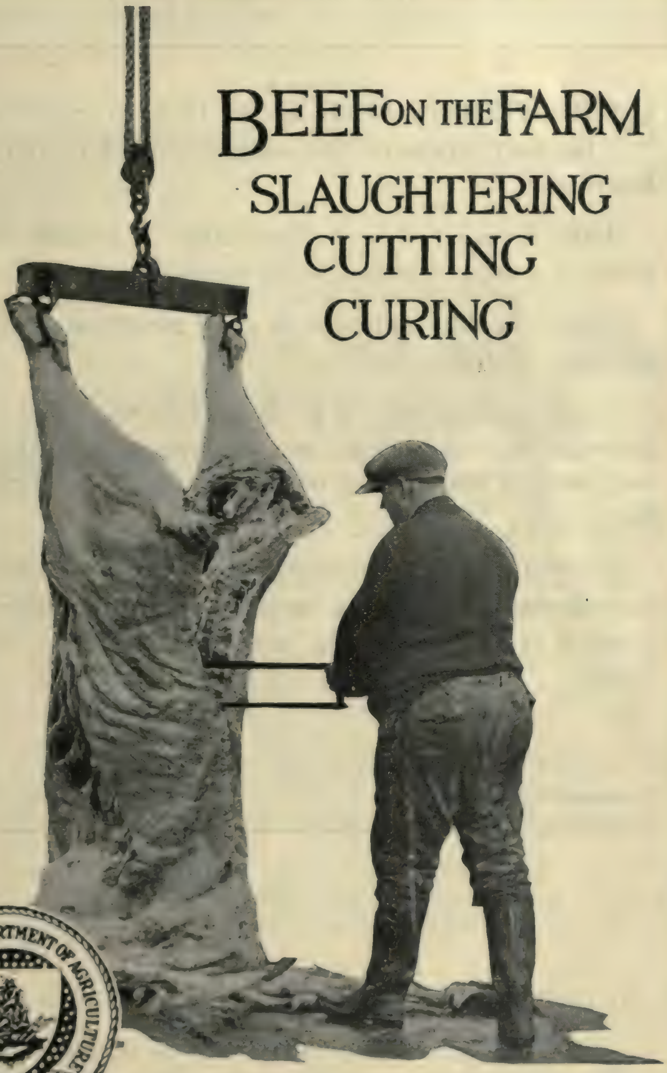
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1415

BEEF ON THE FARM

SLAUGHTERING
CUTTING
CURING



SLAUGHTERING BEEF on the farm or ranch is the only means of obtaining fresh beef in many localities.

Home dressing of beef often makes it possible to procure meat at a considerable saving.

Blocky, healthy animals, in good condition, yield the most desirable beef.

Simple equipment and methods, described and illustrated in this bulletin, enable farmers to follow each step in the process of converting live animals into meat.

It is believed the procedure set forth in this bulletin provides a practical, modern, and satisfactory method of killing, cutting, and curing beef on the farm.

Washington, D. C. Issued May, 1924

BEEF ON THE FARM—SLAUGHTERING, CUTTING, CURING.

By W. H. Black, *Animal Husbandman*, and E. W. McComas, *Assistant Animal Husbandman, Animal Husbandry Division, Bureau of Animal Industry.*

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SELECTING CATTLE FOR SLAUGHTER.

IT IS IMPORTANT that only healthy cattle be slaughtered for beef. A bright eye, sleek coat of hair, and vigor are indicative of health. Cattle should be at least moderately fat, as the meat from a thin animal is less nutritious and palatable. An animal of beef breeding will generally yield the most desirable beef. The meat from such an animal, in good condition, will ordinarily be well marbled; that is, each of the bundles of muscle fibers will be surrounded by a covering of fat, and there will be a rather smooth, even layer of fat over the outside of the carcass just under the hide. The fat of most dairy-bred animals, on the other hand, is not uniformly distributed throughout the meat, but appears on the outside and the inside of the carcass.

Meat from aged animals is more liable to be tough than that from growing animals; however, meat from the former, properly fattened, is preferable to that from young ones in poor condition. Formerly it was believed that meat from beef animals under 30 months of age was watery and lacking in flavor, but in recent years improved methods of feeding and development of the breeds with respect to early maturity have resulted in the production of beef of excellent quality from young animals.

The dressing percentage (per cent of dressed beef to live weight of animal) for beef cattle varies from approximately 45 to 68 per cent. Steers grading from medium to good should yield from 53 to to 56 per cent dressed meat.

CARE OF CATTLE BEFORE SLAUGHTERING.

Cattle should not be fed within 24 hours of the time they are to be slaughtered, but should have access to fresh water. An animal should never be killed while in an excited or overheated condition, as it will not bleed well. Beef from animals not properly bled does not keep well.

Bruising the body just before slaughter will cause bloody spots, which have to be trimmed out, resulting in considerable waste.

EQUIPMENT.

A tree having a limb at least 12 feet from the ground to permit hoisting the dressed carcass, with the aid of block and tackle, beyond the reach of dogs or other animals, provides a suitable place for slaughter. In the absence of a suitable tree, three poles or pieces of rough lumber may be fastened together at one end with a chain or rope and set up in the form of a tripod.

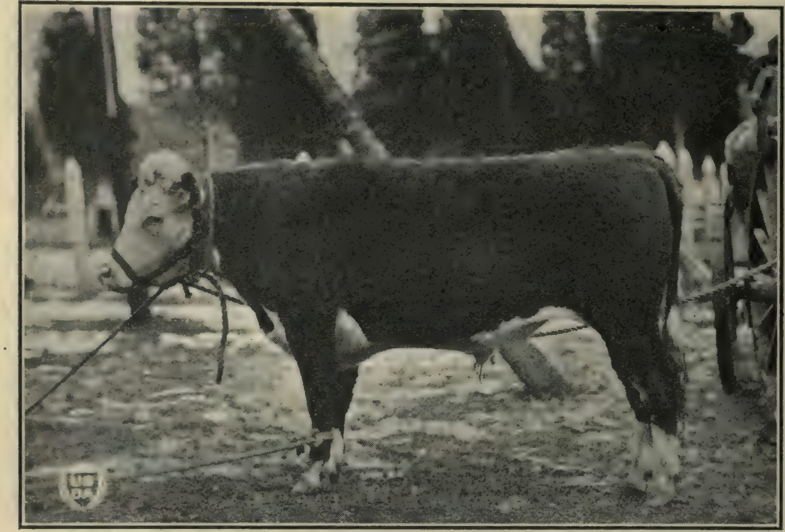

FIG. 1.—Animal tied in position for stunning.

A 2-horse evener (doubletree) with screw-bolt clevises (fig. 20) makes an excellent support and spreader for the carcass. A heavy neck yoke may be used in place of the doubletree.

A pritch (fig. 6) can be made by using a stick about 2½ feet long and sharpening each end, or by fitting a sharp spike in each end.

An ax, a meat saw with a heavy blade, a knife with a curved blade for skinning, a steel, a bucket, a clean cloth, and water are needed for slaughtering. A steak knife with a straight blade 12 or 14 inches long can be used to advantage in cutting up the carcass but it is not absolutely necessary.

SLAUGHTERING CATTLE.

Stunning.—The killing should be done where the carcass is to be hoisted. First, tie the head securely in a position that will enable a man to stun the animal by a blow on the forehead, with an ax or sledge (fig 1). The proper place to strike is just above the center of the forehead.

Bleeding.—It requires skill to stick an animal properly. Stretch the neck out as far as possible, holding it in position with one foot against the jaw (fig. 2). With the sticking knife, cut through the skin from the breastbone toward the throat, making a cut about 10 to 12 inches in length. Insert the knife with the back of the blade against the breastbone and point the tip directly toward the backbone at the top of the shoulders, just under the windpipe, and cut forward toward the head. This will sever the carotid arteries at the point where they fork. Care should be taken not to stick too deep and too far back, as there is danger of penetrating the chest cavity, permitting the blood to drain back on the ribs and stain the carcass. Bleeding may be made more complete by pumping the carcass by grasping the tail and pushing the paunch forward with the foot.

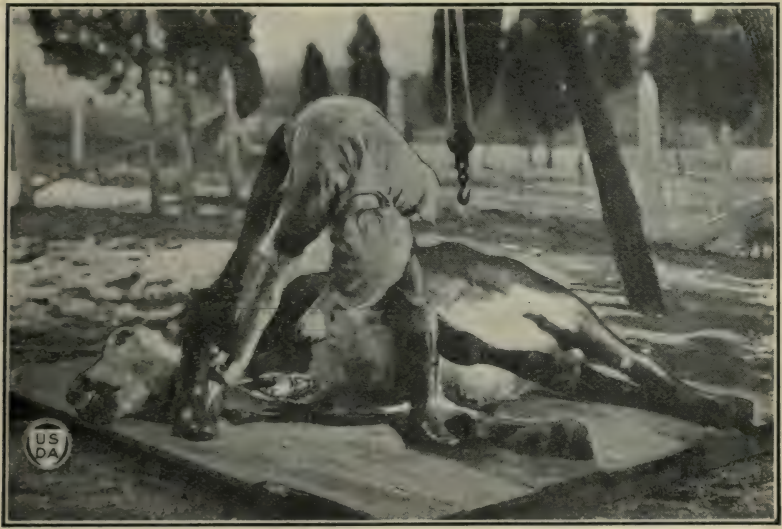
FIG. 2.—Sticking.

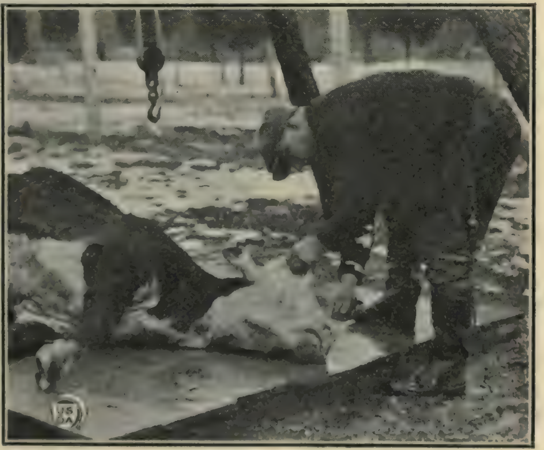
FIG. 3.—Skinning the head—first operation.

Skinning. — Begin at the head, cutting back of the poll, thence to the nostril on the left side of the head along the line of the eye (fig. 3). Skin the side of the head and a short distance down the neck. Raise the head to finish skinning it (fig. 4). Cut across the neck just behind the jaws and unjoint the head at the "atlas" joint (fig. 5).

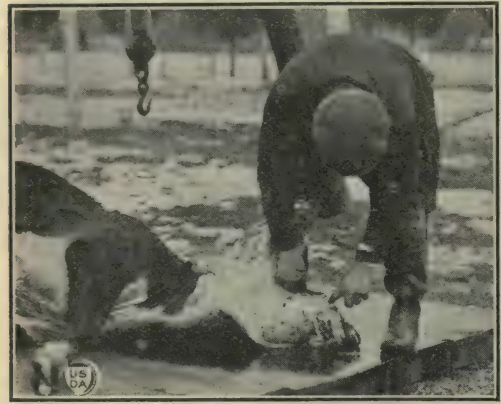

FIG. 4.—Skinning the head—the last operation before detaching it.

Roll the carcass on its back and prop it with a pritch (fig. 6). Split the skin over the back of the forelegs from the dewclaws to a point 2 or 3 inches above the knee. Skin around the knees and shins (fig. 7), unjoint, and skin down to the hoofs (fig. 8).

Cut across the hind leg at the joint below the hock, severing the tendons to permit the leg to relax (fig. 9). Split the skin from the dewclaws to the hock and up over the rear of the thigh to a point from 4 to 6 inches back of the cod or the udder (fig. 10). Skin the hock and shin and sever the leg at the lowest joint of the hock (fig. 11). In splitting the skin over the thigh, the knife should be turned down flat, with the edge pointed outward and a little upward to avoid gashing the flesh (fig. 12). The inside of the thigh may be skinned well down but the outside should not be skinned until after the beef has been raised (fig. 13). Before raising the carcass, split the skin down the middle of the belly from the brisket to the tail and skin back from this line until the side is well started (fig. 14).

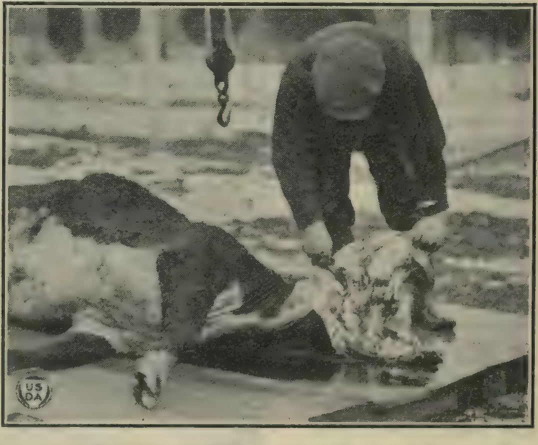

FIG. 5.—Detach the head by cutting across the neck just back of the jaw.

The next, and the most particular part of the skinning operation, is known as "siding." The skinning knife should have a smooth, keen edge. Grasp the handle well up toward the blade and hold the knife blade flat against the surface of the hide which must be stretched tightly (figs. 15 and 16). Remove the skin with the blade turned slightly toward the skin in order to avoid gashing the flat muscle covering the abdomen, or the thin "fell" membrane which lies between the meat and the skin. This membrane serves to protect the meat from drying out and from the attack of molds.

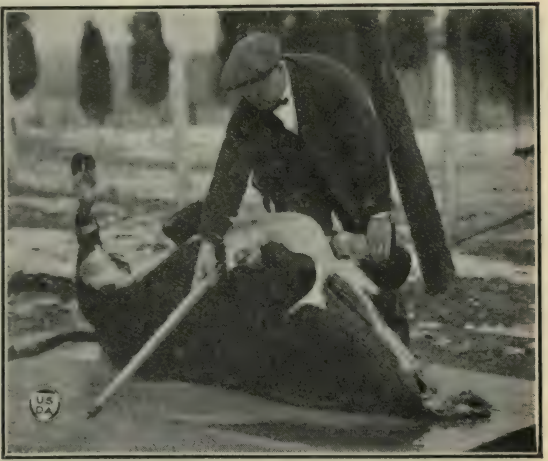

Fig. 6.—Propping the carcass in position with a pritch.

The appearance of the carcass will be improved if all blood spots are wiped from the surface during the skinning operation. A bucket of warm water and cloth are needed for this purpose. The cloth should be wrung dry, with as little water as possible.

Opening the abdominal cavity.—Beginning just back of the brisket, cut through the abdomen carefully so as to avoid puncturing the paunch or intestines and protect them from the knife blade with the left hand, opening the cavity along the midline to the pelvic arch (fig. 17). It is a good plan to hold the knife blade with point up, the hand inside the abdominal cavity. Cut through the brisket, exposing the breastbone, and saw through the latter (fig. 18). Loosen the windpipe and gullet, but do not cut them off. Saw or split the pelvic bone, which is exposed by cutting through the muscle midway between the hind legs (fig. 19). Remove the caul fat.

Hoisting.—Prepare the carcass for hoisting by making an incision between the large tendons and the hock and attaching a spreader. Raise the carcass until the tail head is about even with the skinner's waist. Cut through the hide on the underside of the tail

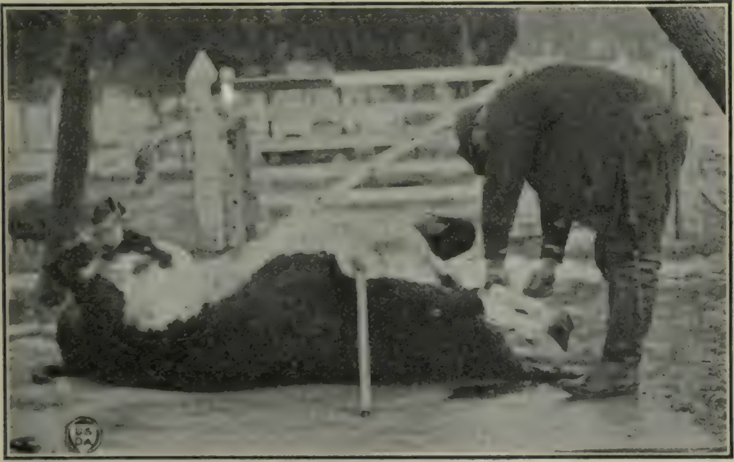

Fig. 7.—Skinning the foreleg.

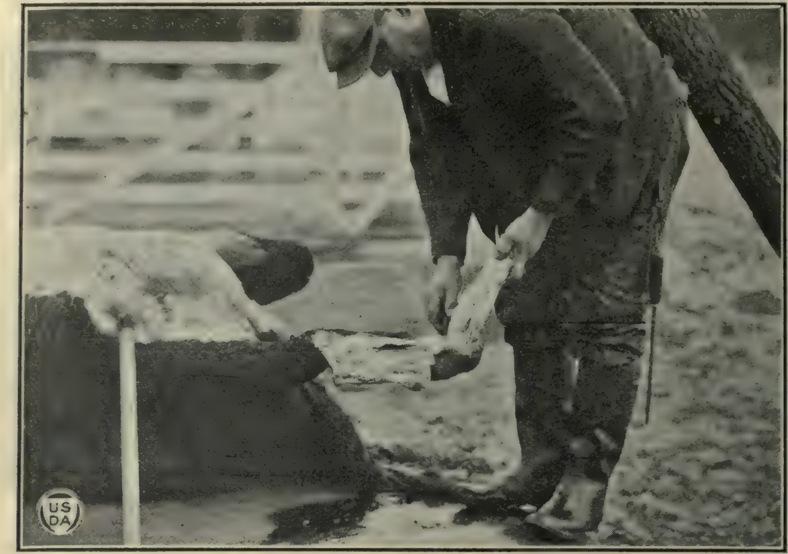

FIG. 8.—Freeing the shank and hoof.

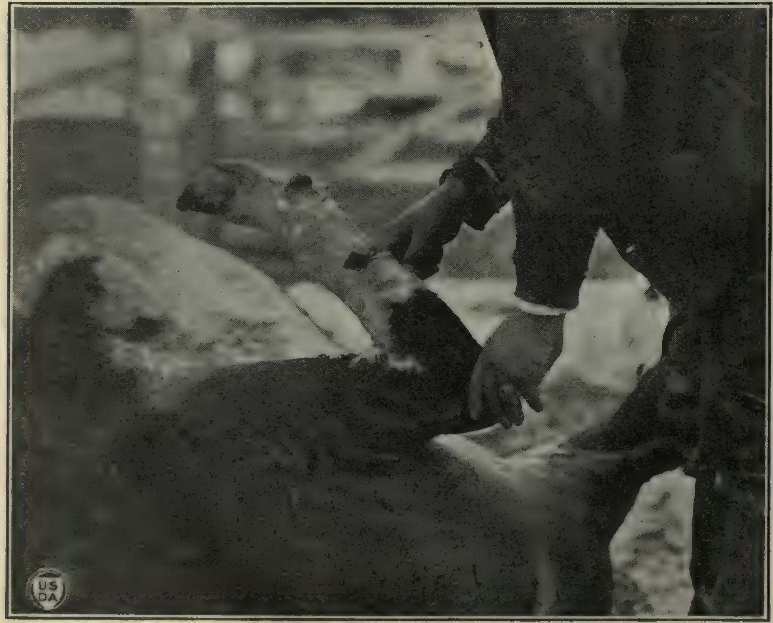

FIG. 9.—Severing the tendons to permit leg to relax.

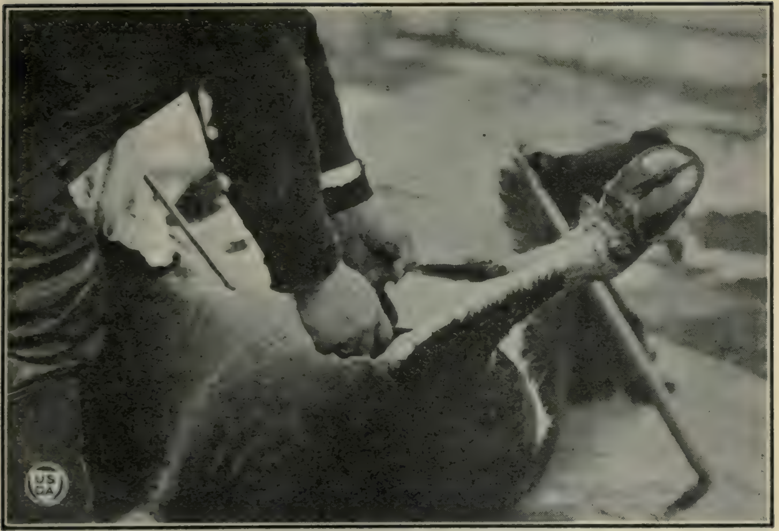

FIG. 10.—Skinning the hind shank.

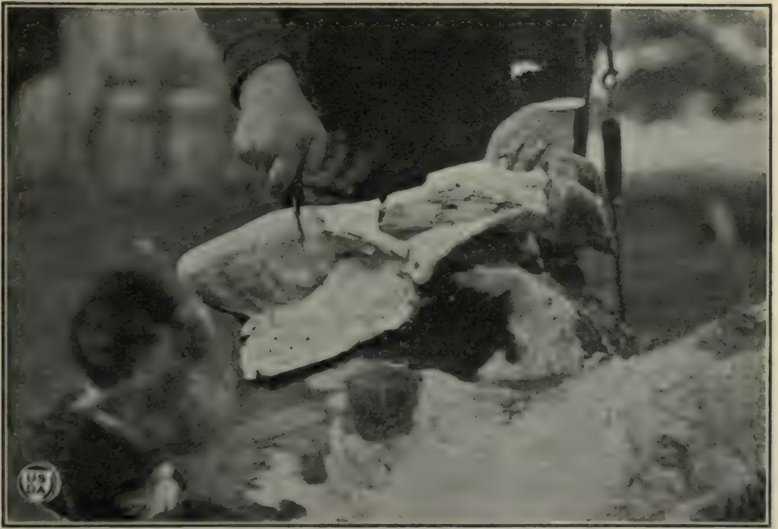

FIG. 11.—Removing hind shank at lower hock joint.

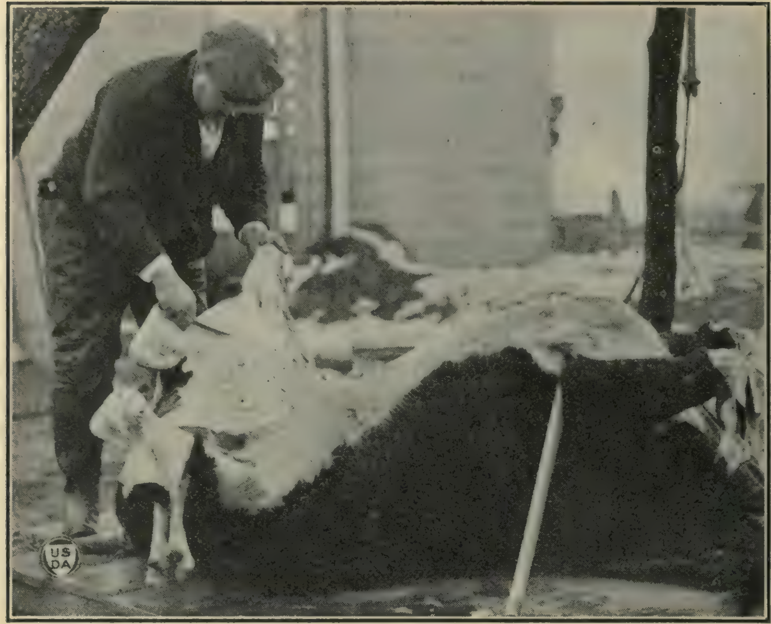

FIG. 12.—Skinning the thigh.

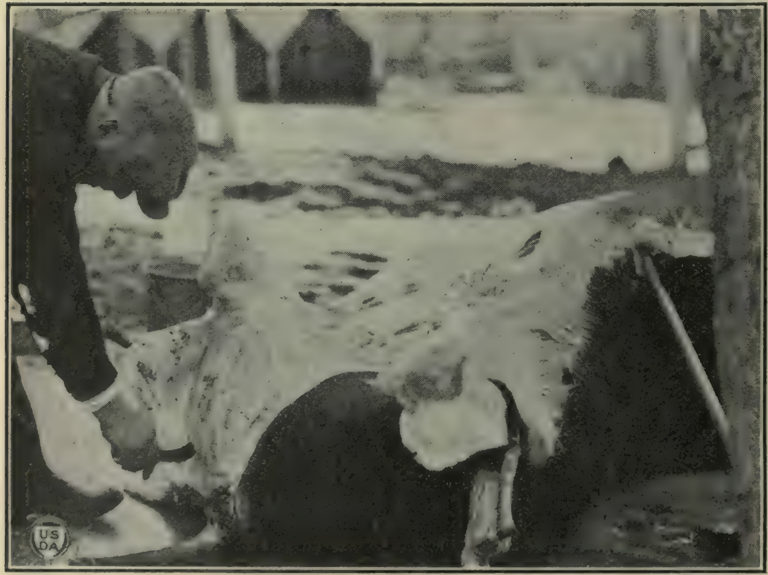

FIG. 13.—The thigh is only partly skinned before hoisting the carcass. It is more convenient to complete the skinning when hoisted, and is also conducive to cleanliness.

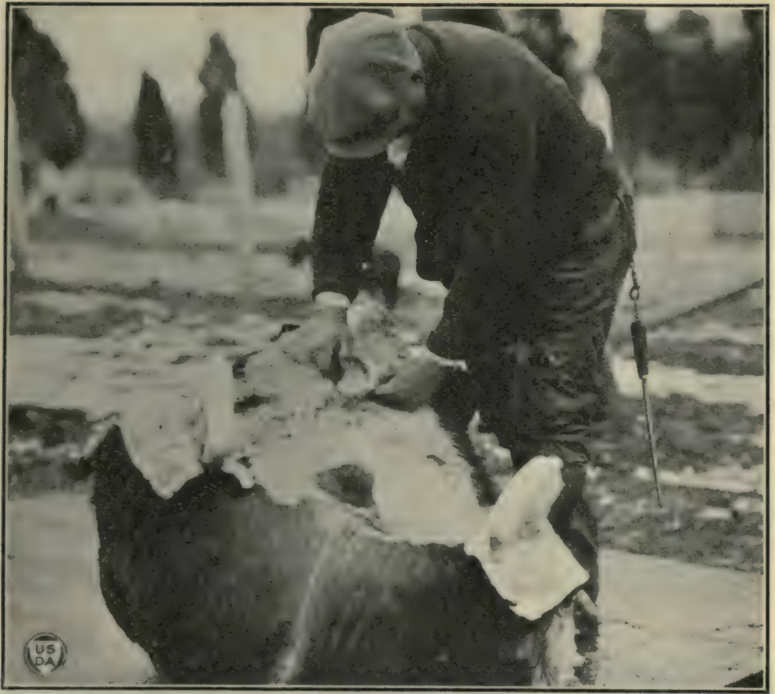

FIG. 14.—Opening the hide on a line from brisket to tail.

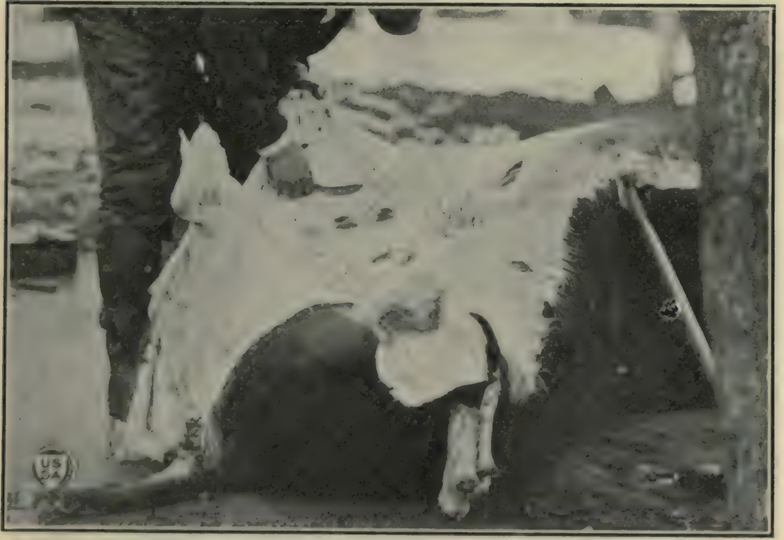

FIG. 15.—Siding. The hide is held with the hand on the outside, for both convenience and cleanliness.

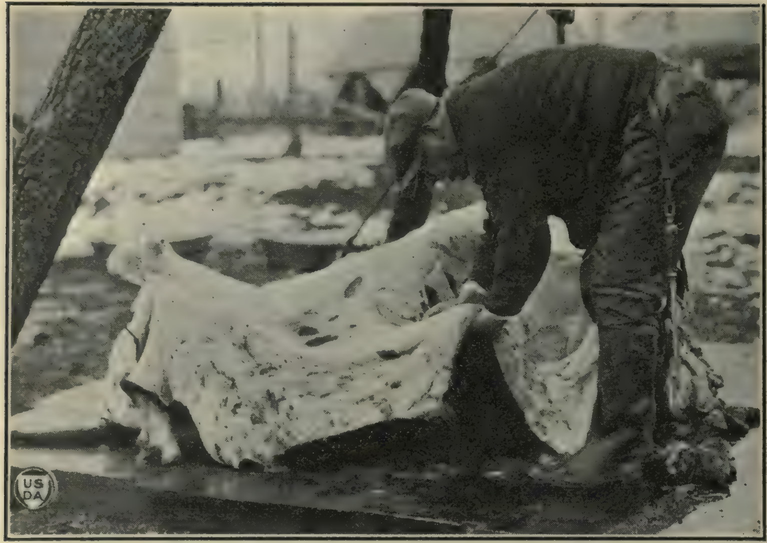

FIG. 16.—Siding is the most difficult part of the skinning operation. Care should be taken to avoid gashing the flat muscle covering the "fell" membrane.

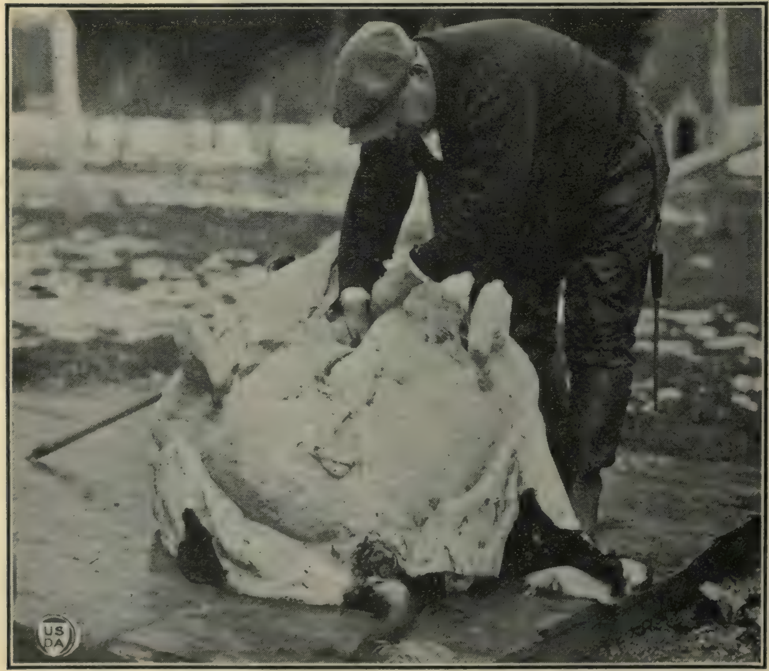

FIG. 17.—Opening the abdominal cavity.

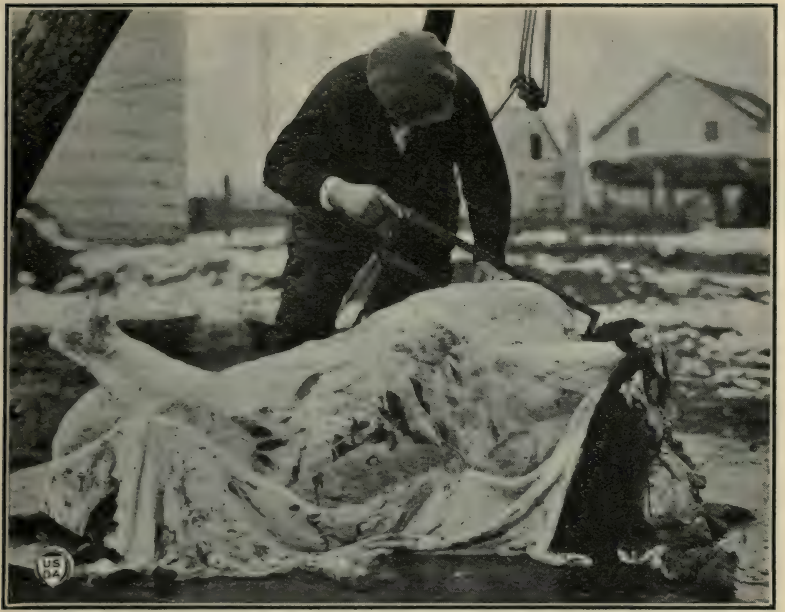

Fig. 18.—Sawing the breastbone.

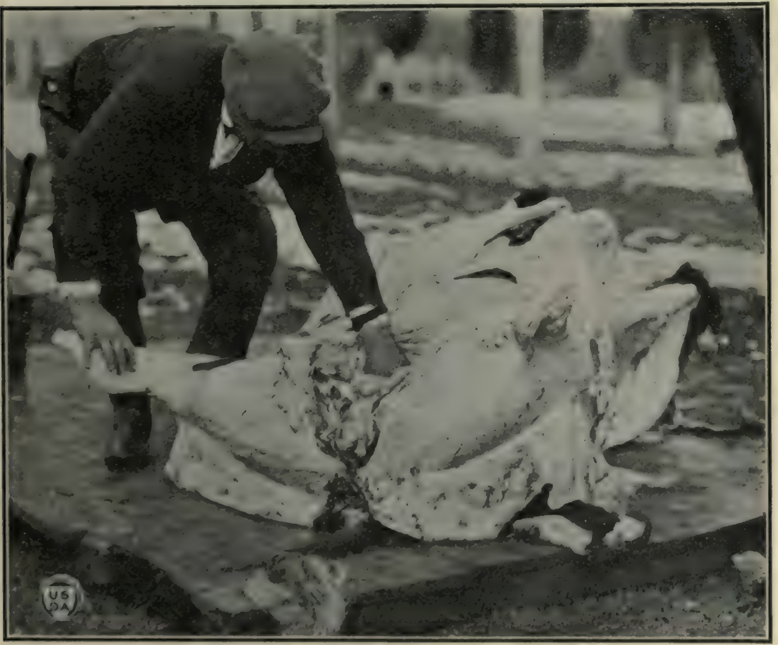

Fig. 19.—The pelvic bone divided.

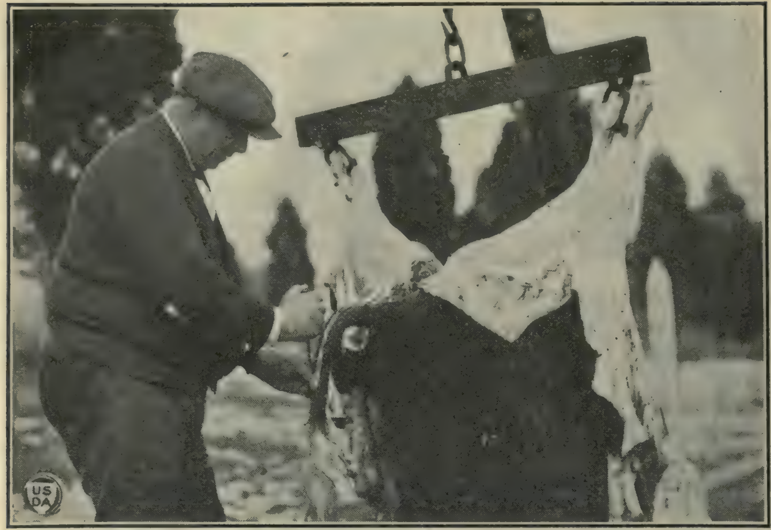

FIG. 20.—-Opening the hide on the underside of the tail.

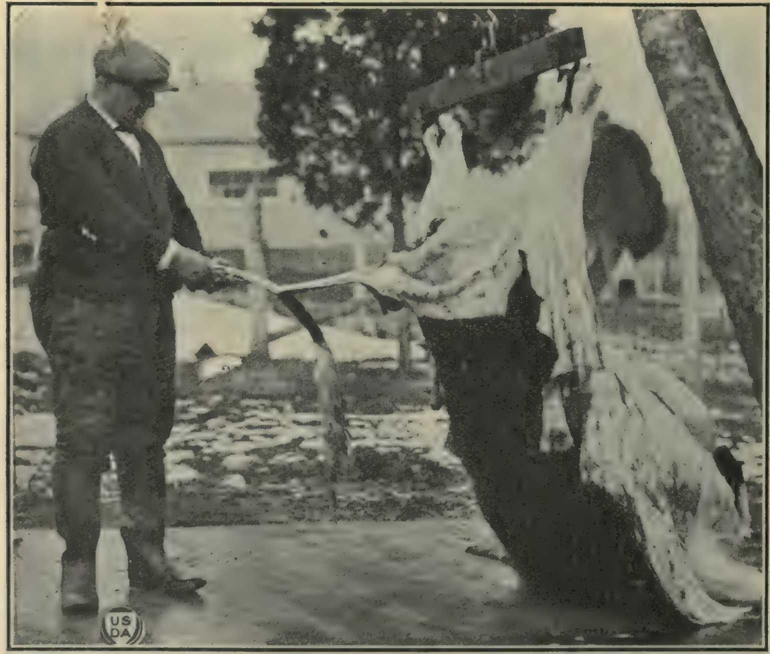

FIG. 21.—Pulling the tail out of the hide.

(fig. 20). Sever the tail bone at a joint near the base and pull it out of the hide (fig. 21). Skin the rump on each side of tail (fig. 22). Hoist the carcass a little for convenience and skin the hide from the hind quarters. The hide may be removed from the thighs by pulling and jerking (fig. 23). When it does not yield readily it may be loosened a little with the knife. As in siding, one should be careful to avoid removing the fell with the hide. Wipe the hocks and hind quarters with a clean cloth dipped in hot water and wrung dry. Next, loosen the rectum and small intestines and let them drop down over the paunch, to permit sawing (fig. 24). With the knife free the liver from the intestines. Pull down on the paunch to tear it loose from the carcass and let it fall into a container (fig. 25).

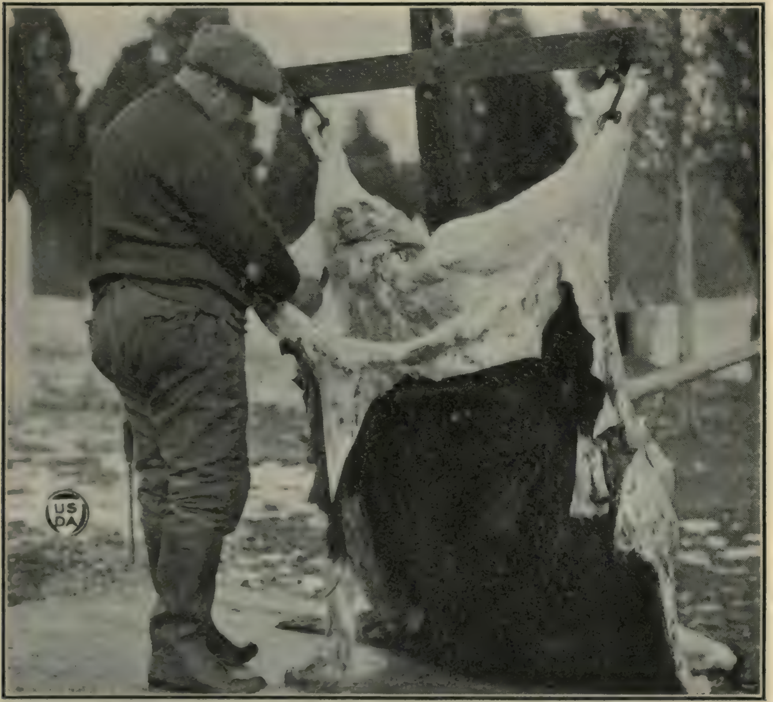

FIG. 22.—Skinning the outside of the thigh (rump).

Hoist the carcass until it clears the ground. Remove the liver and cut the gall bladder from it. Cut out the diaphragm (the sheet of muscle which separates the heart and lungs from the stomach and intestines) but allow the muscles of the diaphragm to remain attached to the carcass. Take out the heart, lungs, and gullet (fig. 26). Skin down the back and remove the hide (fig. 27).

Splitting the carcass.—Divide the carcass into halves, as shown on the title page and in Figures 28 and 29, by sawing down the center of the backbone or by splitting with a sharp ax. Wash all blood from the carcass and wipe dry with the cloth. Move each foreleg up and down several times, to aid in draining the blood from the vessels in the shoulders. The appearance of the carcass may be improved by trimming off the ragged edges.

Removing tongue and brain, and stripping fat from offal.—In removing the tongue from the head, place the head face down, cut along the inner surface of the lower jaw, lift up the tongue and cut it off at the base (fig. 30). A hatchet or cleaver is sometimes used in cutting the bones at the base of the tongue. Allow the fat to remain attached to the tongue. Wash the tongue well in clean, cold water and scrape it with a knife, from the tip to the base, then hang it up to cool. Saw or split the skull and lift out the brains (fig. 31).

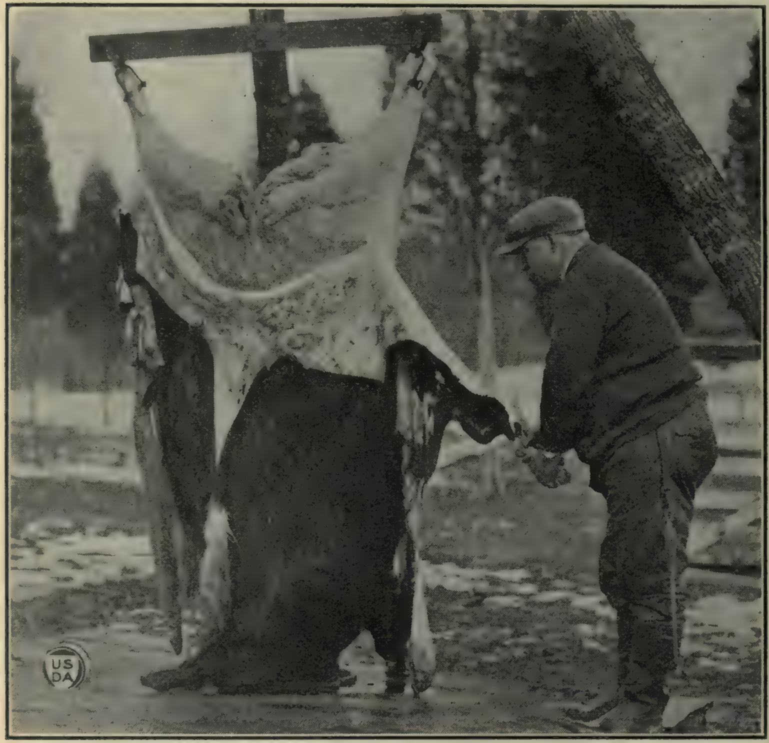

FIG. 23.—Pulling the hide from the thighs.

Trim the fat from the intestines and paunch, as it can be rendered and mixed with lard, or used in making soap.

Cleaning the tripe.—Tripe is made from the first and second stomachs. It may be prepared by cutting off these two stomachs and emptying their contents by turning them inside out. They should then be washed thoroughly and rinsed several times in clean, cold water.

EXAMINING THE CARCASS.

All the internal organs, as well as the carcass, should be carefully examined at the time of slaughter for disease or other condition that might affect the fitness of the meat for food. The only person qualified to do this properly is a veterinarian educated and trained to perform this important duty. If one is not available, an examination of some value can be made by any one thoroughly familiar with the appearance of normal organs and meat. If a person is not familiar with such appearance he will not be able to recognize changes from the normal. If evidence of disease or change is found, the next point to be determined is whether the condition is local or general. A localized condition affects a limited part only. Bruises, minor injuries, parasites in organs, an inclosed abscess, a single tumor, etc., may be cited as local conditions, and removal of the affected part is usually all that is required. A generalized condition is one which more or less affects the whole carcass. The presence of great congestion or inflammation in the lungs, intestines, kidneys, or on the inner surface of the chest or abdominal walls is to be regarded as showing generalized conditions. Numerous yellowish or pearl-like growths scattered through the organs or on inner surfaces of chest or abdominal walls indicate generalized tuberculosis. An abnormal color of the meat is usually due to some generalized condition. All generalized conditions are to be viewed seriously. Any such case should be submitted to a graduate veterinarian for examination and opinion as to the fitness of the meat for food.

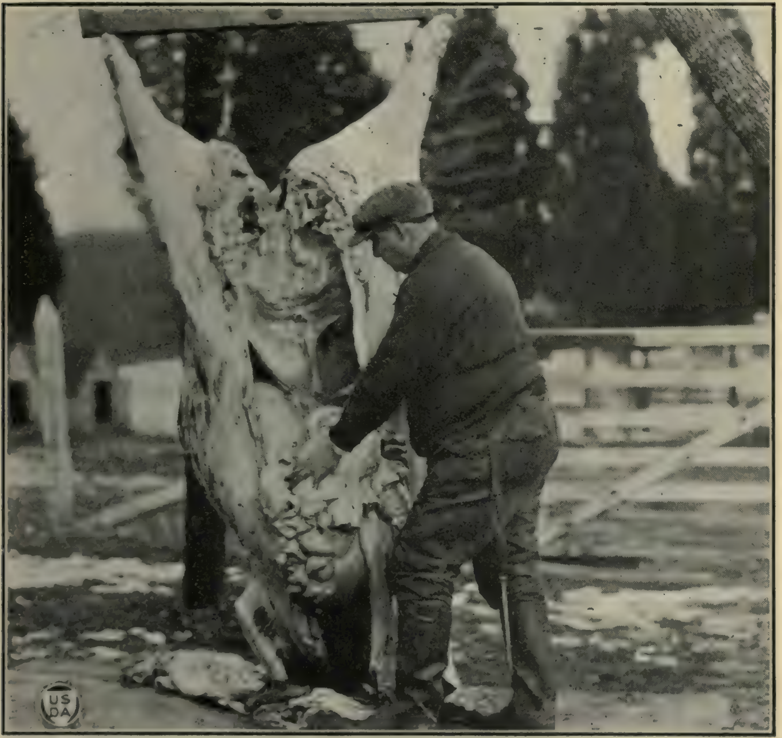

Fig. 24.—Loosening the offal.

COOLING THE CARCASS.

A beef carcass should be allowed to hang from 12 to 24 hours, or at least long enough to cool, before being cut. On the other hand, it is not a good practice to permit the carcass to freeze. When circumstances permit, killing should be done on a day when the beef can be cooled at a temperature ranging from 34° to 40° F. When all the animal heat is out of the carcass, it should be firm enough to cut well. After cooling, the carcass may be quartered and hung in a clean, dry place which is free from dust, insects, and objectionable odors. Moisture aids in the decomposition of beef and for this reason it is important that the carcass be kept in as dry a place as possible. Sunlight and wind darken and dry the meat.

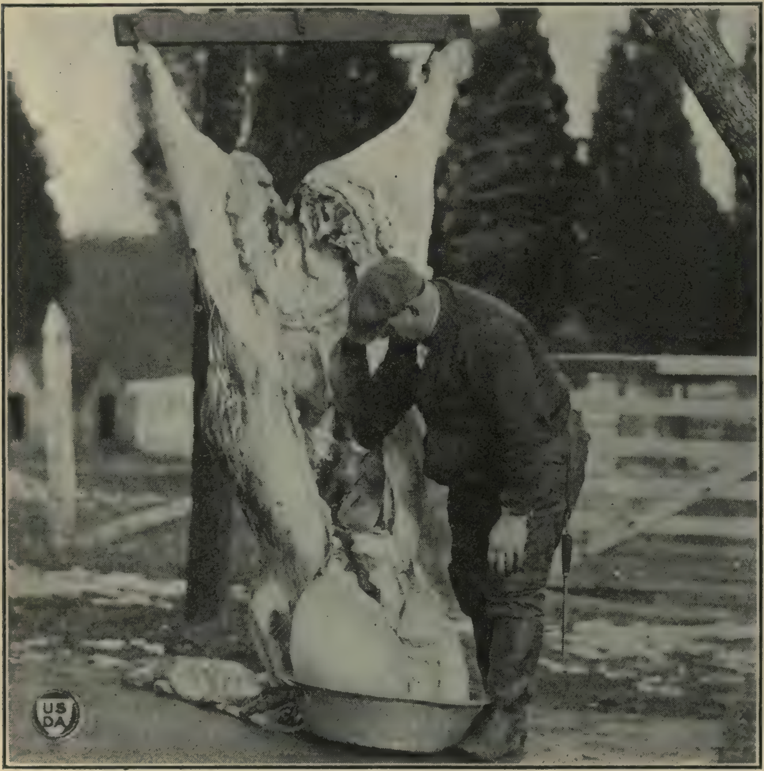

FIG. 25.—Removing the offal.

Beef becomes more tender and palatable when allowed to ripen or age for a short time. When conditions permit, it may be allowed to hang from two to three weeks before being cut up.

CUTTING UP THE CARCASS.

Quartering or "ribbing down."—Insert the knife blade between the twelfth and thirteenth ribs at a point midway between the backbone and flank, marked 1 on the diagram (fig. 32). Cut to the backbone

(2) on a line parallel with the ribs, then cut toward the flank (3), leaving from 6 to 8 inches of flank to hold up the fore quarter when the backbone has been sawed. Saw through the backbone in a line with the knife cut between the ribs, and free the fore quarter from the hind quarter by cutting the flank that is holding them together.

When the quarters are separated, as indicated by the lines from 2 to 3 in Figure 32, the fore quarter will be about 52 per cent by weight of the entire carcass and the hind quarter about 48 per cent. These may be further divided into the following cuts having the approximate yields shown in the table.

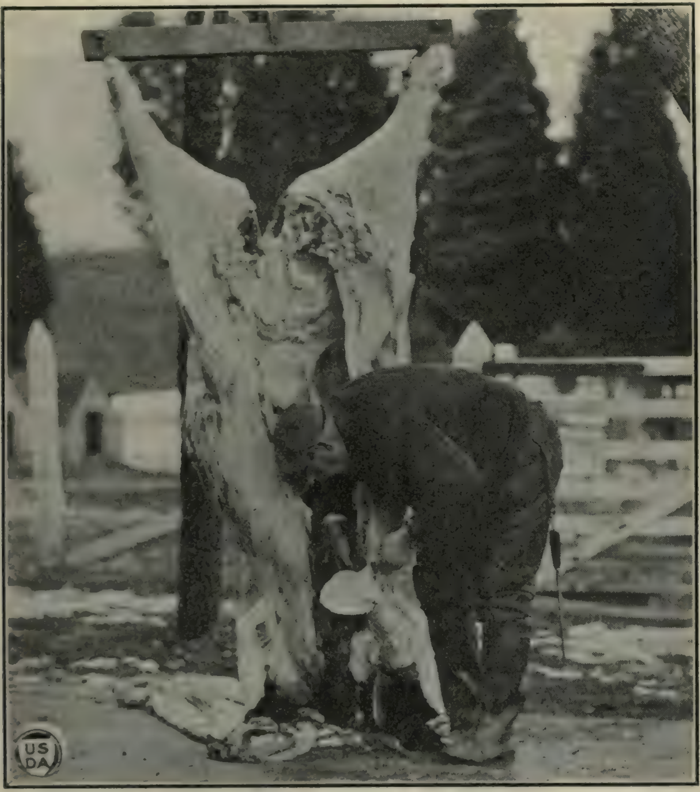

FIG. 26.—Removing the heart, lungs, and gullet.

Principal cuts in a beef carcass and their relative weights.

Fore quarter.	Per cent.	Hind quarter.	Per cent.
Chuck (including neck)	22.15	Loin	16.38
Rib	9.64	Flank	3.53
Plate and brisket	14.46	Round (including rump)	24.09
Fore shank	5.75	Suet	4.00
Total	52.00	Total	48.00

There are many methods of cutting up the carcass. The one described here aims to give pieces suitable for cooking, canning, and corning.

Cutting the fore quarter.—It is better to cut the meat with a knife and use a saw rather than an ax or cleaver for cutting bones. This avoids splintering the bone and causing unnecessary waste of meat. Cut along the line 4 to 5 (fig. 32) to sever the shank (fig. 33), and trim from the brisket. Cut through the meat to the ribs, along line 1 to 5 and line 5 to 4 (fig. 32). Saw along the same line and remove plate and brisket (fig. 34). The plate may be separated from the brisket by cutting along the line 5 to 6 (fig. 32).

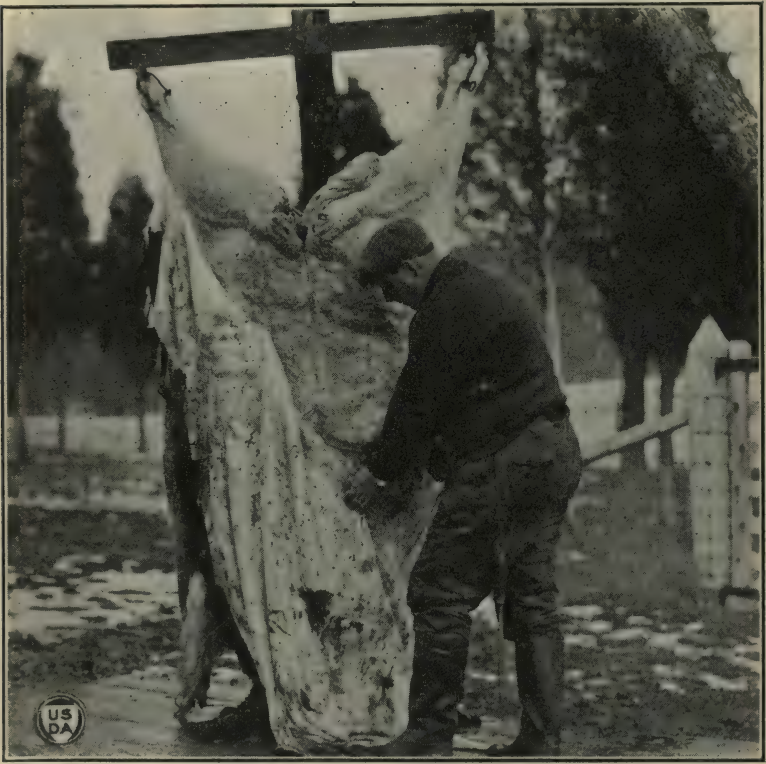

FIG. 27.—Removing the hide from the back.

Cut from 5 to the backbone at 7 (fig. 32) and saw through the backbone to free the seven prime ribs from the chuck (figs. 35 and 36).

Steaks or roasts may be cut from the chuck beginning at the fifth rib and extending to the second rib. The neck may be severed from the chuck by cutting along the line 8 to 9 (figs. 32, 33, and 37).

Cutting the hind quarter.—Lay the hind quarter on the block with the inside of the carcass up and detach the flank by cutting from 10 to 1 (figs. 32 and 38). Remove the kidney (fig. 39) and the fat in which it is embedded. Separate the loin from the round and rump. Start by cutting from point 11, which is midway between the tail head and the low point in the backbone (figs. 32, 40, and 41), to point 10 on a line which passes just in front of the pelvic bone. The loin may be divided into the sirloin and porterhouse at the hip or hook bone (fig. 42). The porterhouse contains most of the tenderloin. Separate the rump from the round by making the cut from line 12 to 13 (figs. 32 and 43), leaving the pelvic bone in the rump. The pelvic bone may be trimmed out of the rump (fig. 44). The shank may be cut off at the upper end of the long bone along the line 14 to 15 (figs. 32 and 45).

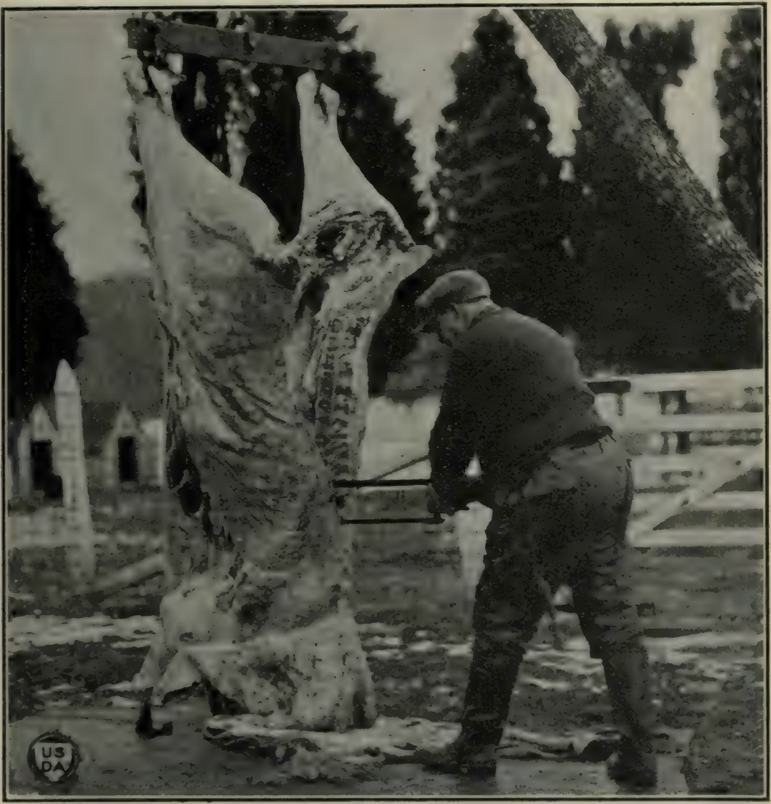

FIG. 28.—Sawing the backbone.

CURING BEEF.

The corning or pickling process is used to preserve the surplus beef for future use. Salt, sugar, and saltpeter are generally used. Salt cures the meat and extracts water from the tissues, tending to make it hard and dry. The action of saltpeter is similar to that of salt, but in addition gives the meat a reddish or pink color. Sugar softens the harshness of the salt and improves the flavor of the meat.

Preparing corned beef.—The cheaper cuts of meat, such as the plate, rump, and chuck, are generally used in making corned beef. Meat from fat animals makes better corned beef than that from thinner animals.

Cut the beef into pieces 5 or 6 inches square. These pieces should be of uniform thickness so that they may be packed in even layers in the barrel. When the meat is thoroughly cooled it should be corned as soon as possible, for meat which has begun to spoil is unwholesome and will probably sour during the corning process. Under no circumstances should meat be put in cure while in a frozen condition.

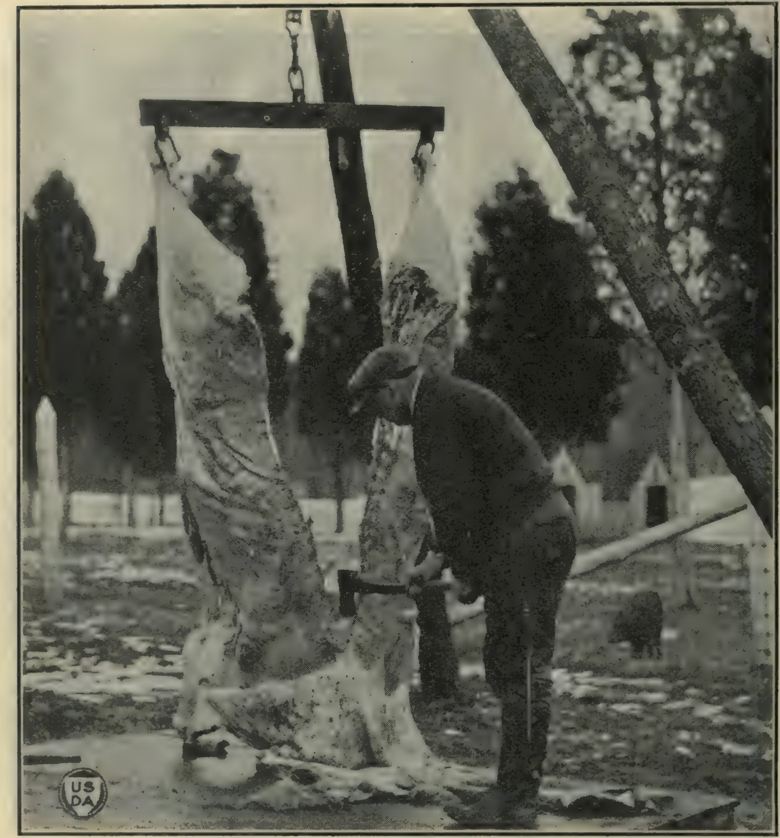

FIG. 29.—Splitting the bones in the neck with an ax.

Weigh the meat and for each 100 pounds allow 8 pounds of salt; sprinkle a layer of salt one-quarter of an inch in depth over the bottom of the vessel (a stone jar or wooden barrel which has been thoroughly cleaned and scoured is preferable); pack the cuts of meat as closely as possible, making a layer 5 or 6 inches thick; then add alternate layers of salt and meat, being careful to cover the top layer of meat with considerable salt.

Allow the salted meat to stand overnight, then add a solution composed of ingredients in the following proportion: For 100

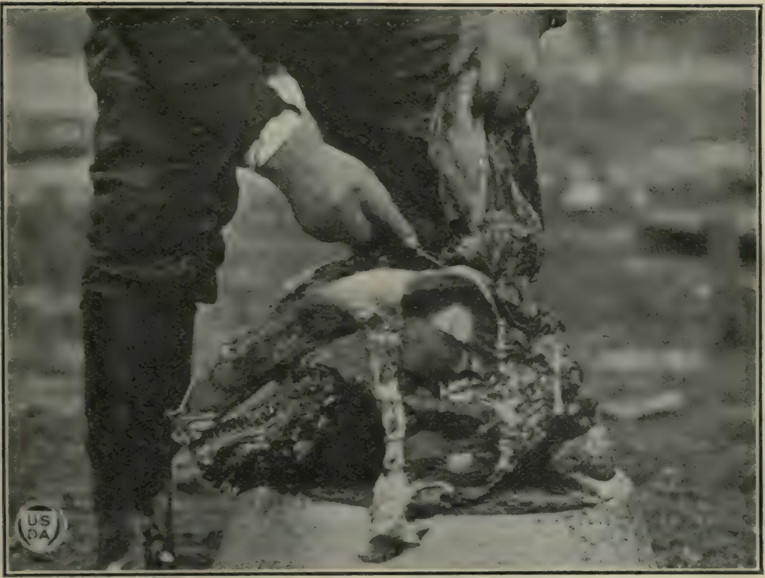

FIG. 30.—Removing the tongue.

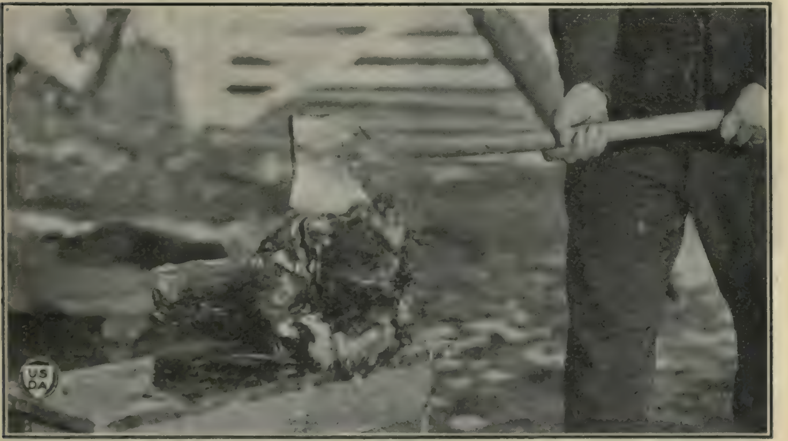

FIG. 31.—Splitting the skull to remove the brains.

pounds of meat use 4 pounds of sugar, 2 ounces of baking soda, and 4 ounces of saltpeter dissolved in 1 gallon of lukewarm water. Mix thoroughly and pour over the meat. Then add 3 gallons of water. Keep the meat entirely under the brine by using a loose board cover with a weight on it. If any of the meat projects it causes the brine to spoil in a short time.

If the meat has been corned during the winter and must be kept into the summer season, it is advisable to watch the brine closely during the spring, as it is more liable to spoil at that time than at any other season. If the brine appears to be ropy, the pieces of meat should be removed and vigorously washed with a stiff brush and hot water, then repacked and covered with new brine. The brine should be kept in a cool place, as the sugar in the brine has a tendency to ferment. To cure thoroughly the meat should be kept in the brine 28 to 40 days. Meat removed from the brine should be hung up and allowed to drain thoroughly before wrapping or smoking.

Drying beef.—The round is commonly used for dried beef, the inside of the thigh being considered the choicest piece, as it is slightly more tender. The round should be cut lengthwise of the grain of the meat in preparing for dried beef, so that the muscle fibers may be cut crosswise when the dried beef is sliced for table use. Cure the meat in the same manner as described under corning, with the exception of adding an additional pound of sugar per 100 pounds of meat. After being removed from the pickle, the meat should be smoked and hung in a dry place or near the kitchen fire, where the water will evaporate from it. It may be used at any time after smoking, although the longer it hangs in the dry atmosphere the drier it will become. The drier the climate, in general, the more easily can meats be dried. In arid regions good dried meat can be made by exposing it fresh (if protected from flies) to the air.

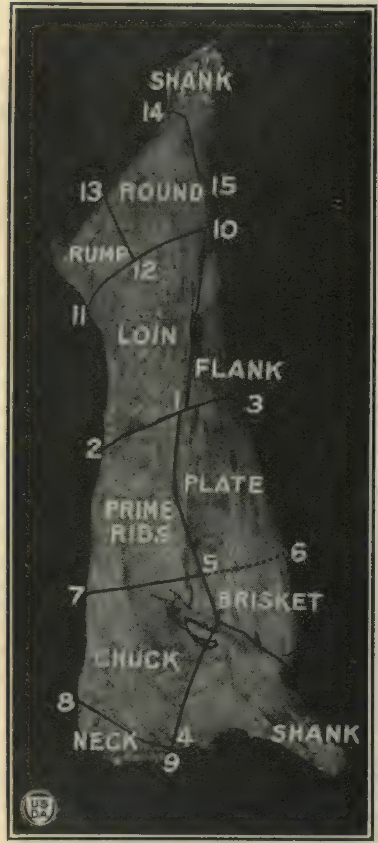

FIG. 32.—Side of beef, with primary cuts outlined.

Smoking beef.—Pickled and cured meats are smoked to aid in their preservation and to give flavor and palatability. The creosote formed by the burning of wood closes the meat pores to some extent, excluding the air, and is somewhat objectionable to insects.

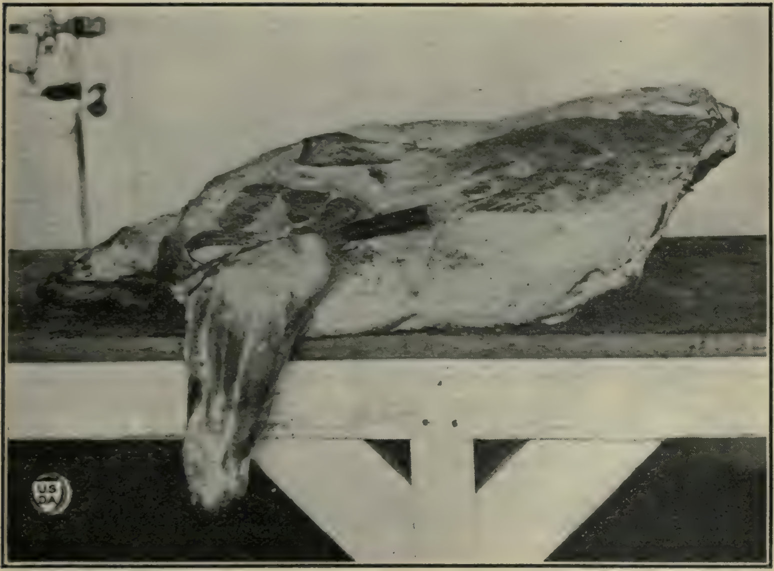

FIG. 33.—Cutting off fore shank.

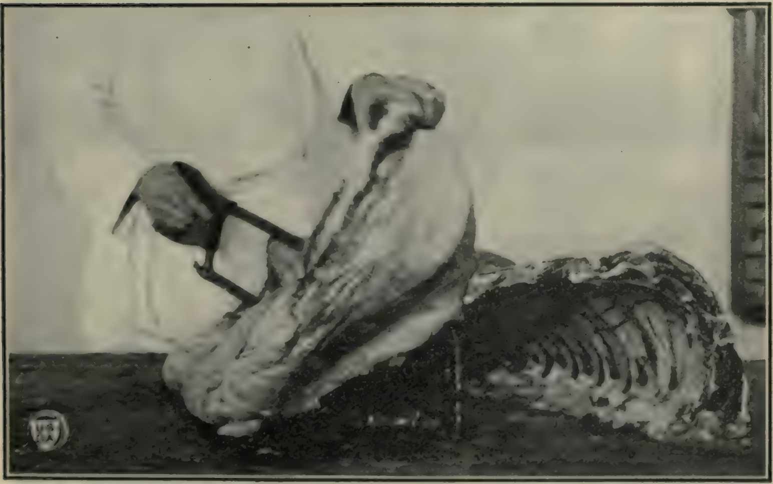

FIG. 34.—Sawing plate from prime ribs and chuck.

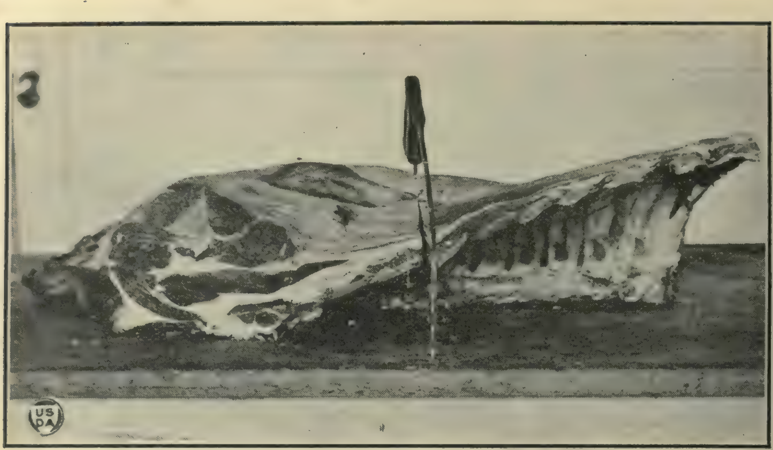

FIG. 35.—Separating prime ribs from chuck.

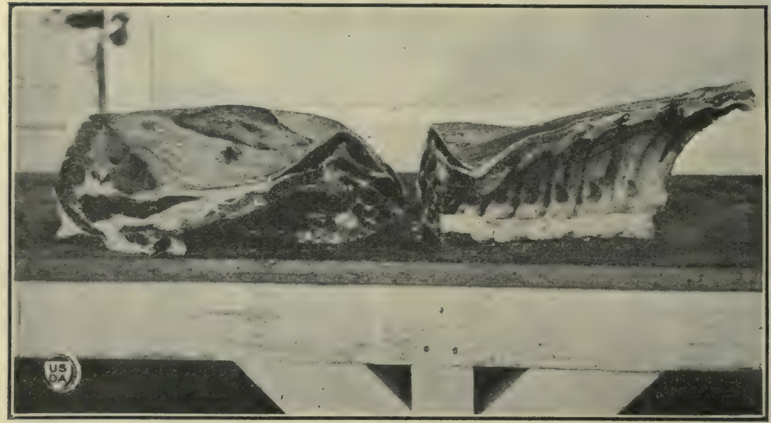

FIG. 36.—Ribs and chuck separated.

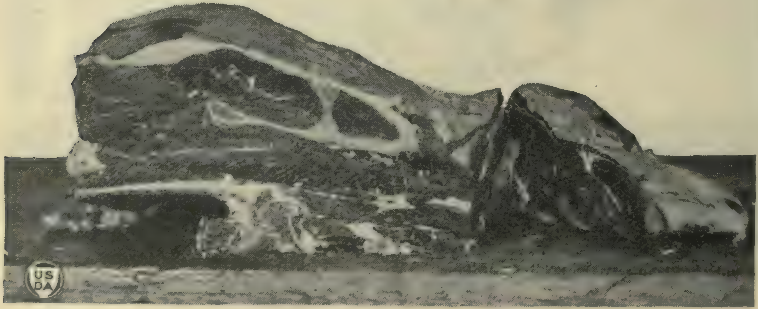

FIG. 37.—Neck cut from chuck.

The smokehouse on the farm.—The smokehouse should be from 8 to 10 feet high to give the best results, and of a size suited to the amount of meat to be smoked. A smokehouse from 6 to 8 feet square is large enough for ordinary farm use. Ample ventilation should be provided to carry off the warm air in order to prevent overheating the meat. Small openings under the eaves or a chimney in the roof are sufficient if arranged so as to be easily controlled. A fire pot outside of the house, with a flue through which the smoke may be conducted to the meat chamber, gives the best condition for smoking.

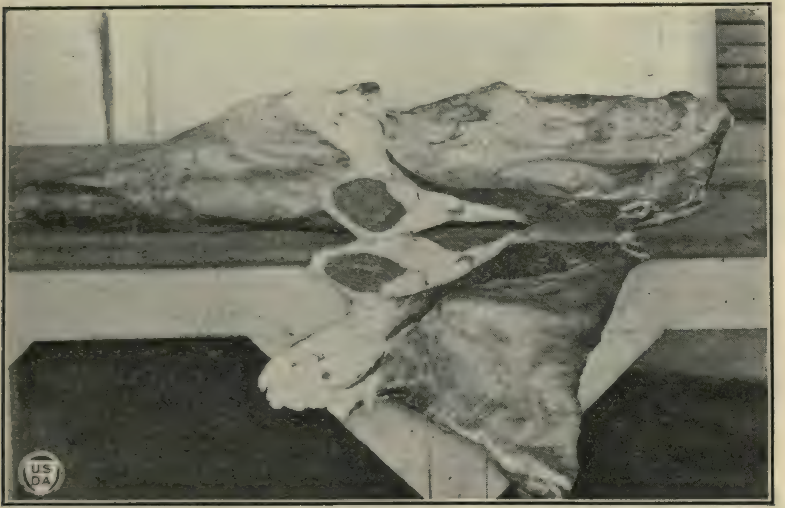

FIG. 38.—Cutting off the flank.

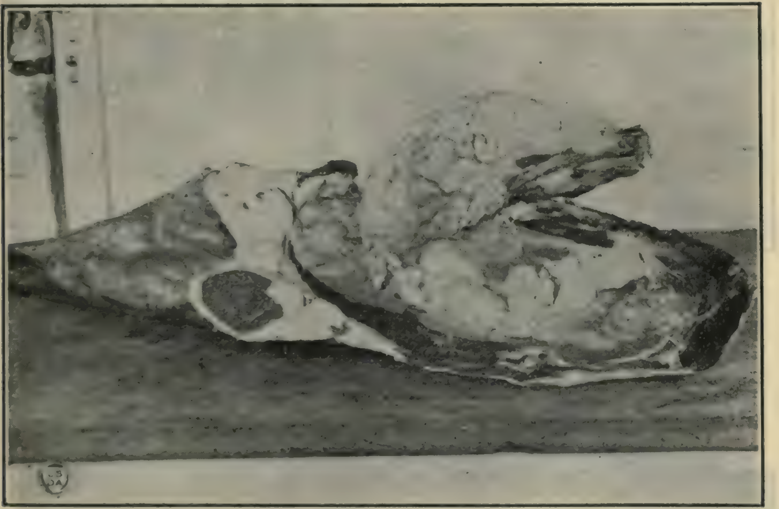

FIG. 39.—Removing the kidney and kidney fat.

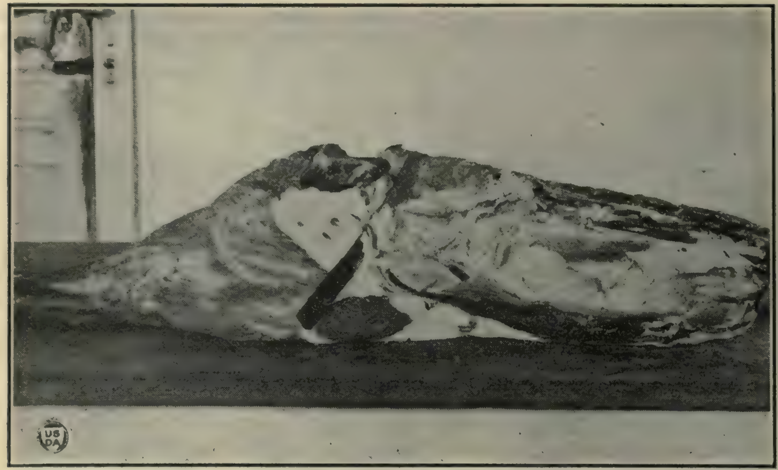

FIG. 40.—Cutting off the loin just in front of the pelvic bone.

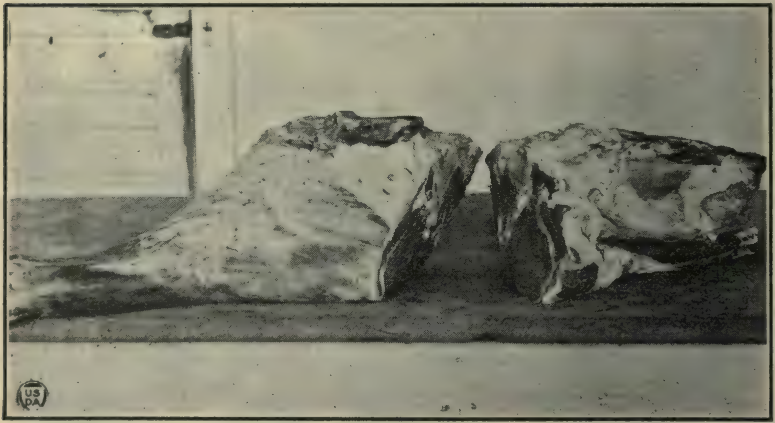

FIG. 41.—The loin, detached from the round and rump.

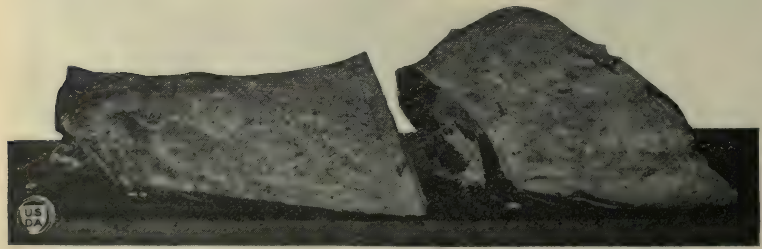

FIG. 42.—Sirloin (right) and porterhouse (left)—side view.

When this is not available, a fire may be built on the floor of the house and the meat shielded by a sheet of metal. The construction should be such as to allow the smoke to pass up freely over the meat and out of the house.

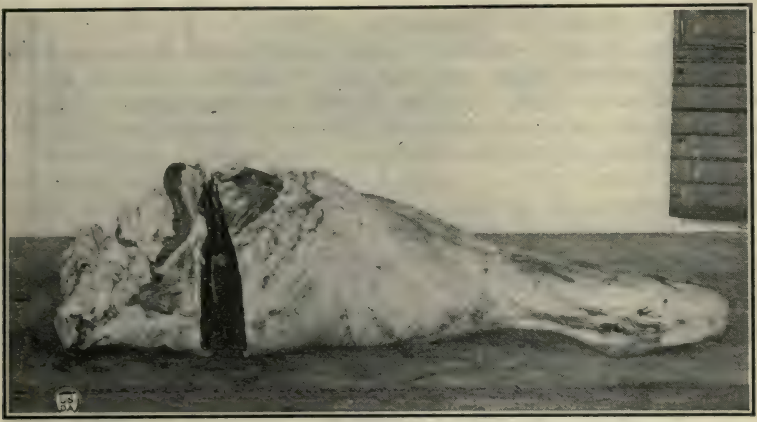

Fig. 43.—Separating the rump from the round.

Brick or stone houses are best, though the first cost is greater than if built of lumber. Large dry-goods boxes and even barrels may be made to serve as smokehouses where small amounts of meat are to be smoked. The care of meat in such substitutes is so much more difficult and the results so much less satisfactory, that a permanent place should be provided if possible.

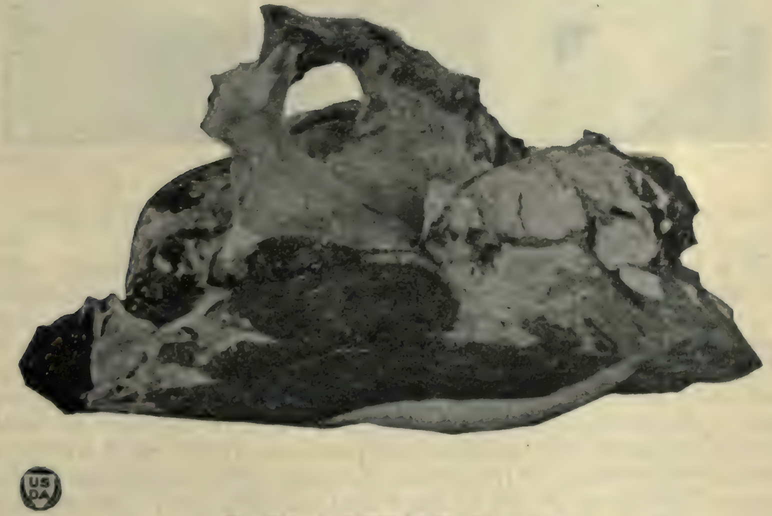

Fig. 44.—A step in boning the rump.

The best fuel for smoking meats is green hickory or maple wood smothered with sawdust of the same material. Hardwood of any kind is preferable to soft wood. Resinous woods should never be used, as they are liable to impart bad flavors to the product. Corncobs are a good substitute for hard wood and may be used if desired. Soft wood gives a large amount of soot in burning and this is deposited on the meat, making it dark in color and rank in flavor. Juniper berries and fragrant woods are sometimes added to the fire to flavor the meat.

Meat that is to be smoked should be removed from the brine 2 or 3 days before being put into the smokehouse. If it has been cured in a strong brine it is best to soak the pieces about 3 hours in cold water to prevent a crust of salt from forming on the outside when the beef is smoked. Washing the meat in tepid water and scrubbing clean with a brush is a good practice. The pieces should then be hung up to drain. After being drained they may be hung in the smokehouse. The meat should be suspended below the ventilators and should hang so that no two pieces touch each other, as contact prevents uniform smoking.

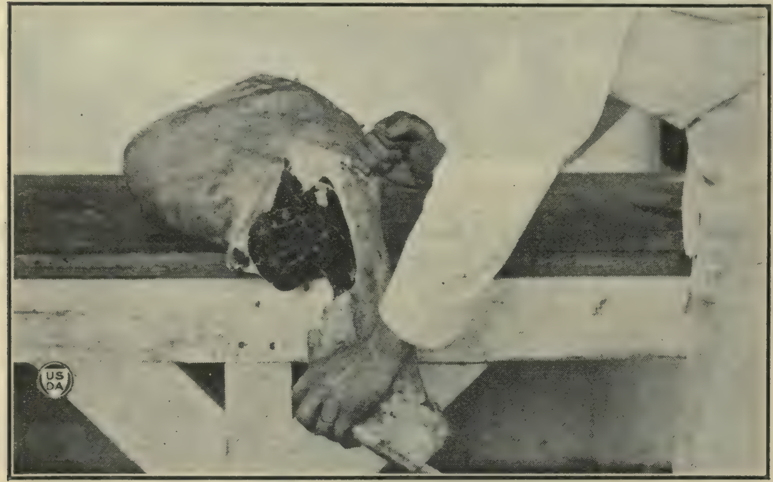

FIG. 45.—Removing hind shank.

It is best to keep the fire burning slowly and continuously until the smoking is completed, holding the temperature at about the same point. If the fire is allowed to die down, the meat becomes cold and the smoke does not penetrate readily. As a result, the outside of the meat is heavily smoked but there is little smoke on the inner portions. When the fire is kept going steadily and an even temperature is maintained, from 24 to 36 hours will be required to finish one lot of meat. Smoke does not penetrate frozen meat and it is necessary to extract all frost from the meat before filling the smokehouse. The house should be kept dark at all times to prevent flies from entering. The meat should be cooled by opening the ventilators or doors, as soon as it is smoked sufficiently. When hard and firm, it may be canvased or packed away for summer use.

Smoked meat may be stored in the smokehouse if it is ventilated and free from flies. A dry, cool cellar or attic, with free circulation, is a satisfactory place for smoked meats at all seasons, if it is kept dark and flies are excluded.

After the meat is smoked and has become dry on the surface, it should be wrapped. Newspaper will do, but oiled or waxed paper is preferable. It should then be inclosed in heavy muslin or canvas. As a protection from flies and insects, the muslin or canvas should be covered with yellow wash or ordinary lime whitewash to which glue has been added. Hang each piece so that it does not come in contact with other pieces. Do not stack in piles.

In making yellow wash, for each 100 pounds of meat use 3 pounds of barytes (barium sulphate), 6½ ounces flour, 1¼ ounces chrome yellow (lead chromate), and 1 ounce glue. Mix the flour in a half pailful of water, stirring until smooth. Dissolve the chrome yellow in a quart of water, in a separate vessel, and add this solution and the glue to the other mixture; bring to a boil, adding the barytes slowly and stirring constantly. The wash should be prepared the day before it is to be used. Stir it frequently when using and apply with a brush.

PREPARING BEEF PRODUCTS.

Pickling tripe.—After the tripe has been thoroughly cleaned and rinsed in cold water, it should be scalded in hot water (a little below the boiling point). When sufficiently scalded, the inside lining of the stomachs may be removed by scraping, which will leave a clean, white surface. Tripe should be boiled until tender (usually about three hours) and then placed in cold water so that the fat may be scraped from the outside. When this has been done, peel off the membrane from the outside of the stomach, and the clean, white tripe is ready for pickling.

Place the tripe in a clean, hardwood barrel or earthenware jar, and keep submerged in a strong brine for three or four days. Rinse well with cold water and cover with pure cider vinegar, or a spiced pickling liquid. Place a weight on the tripe to keep it from floating on the surface of the liquid.

Making hamburger.—Grind lean beef, such as the round, neck, flank, and trimmings, and a little fat, in a sausage grinder. If desired, a small amount of bacon may be put in for flavor. For seasoning, about 1 pound of salt and 4 ounces of pepper are sufficient for 50 pounds of meat.

Bologna-style sausage.—In making bologna, for each 20 pounds of beef, 5 pounds of fresh pork may be added. Grind the meat coarse, then add the seasoning and grind through the fine plate. For seasoning 25 pounds of meat, ½ pound of salt, and 2½ ounces of pepper are usually satisfactory. Garlic may be added if desired. From three to four pounds of water may be added to the above-mentioned quantity of meat. Mix with the hands until the water is entirely absorbed by the meat. When thoroughly mixed, stuff it into soaked beef casings or " rounds " and smoke the bologna from two to three hours at a temperature of from 60° to 70° F. After smoking, cook the bologna in water about 200° F., or slightly below the boiling point, until it floats. The sausage should be kept in a dry place for immediate use, or it may be canned by packing in cans, covering to within one-half inch of top with the liquid in which the bologna was

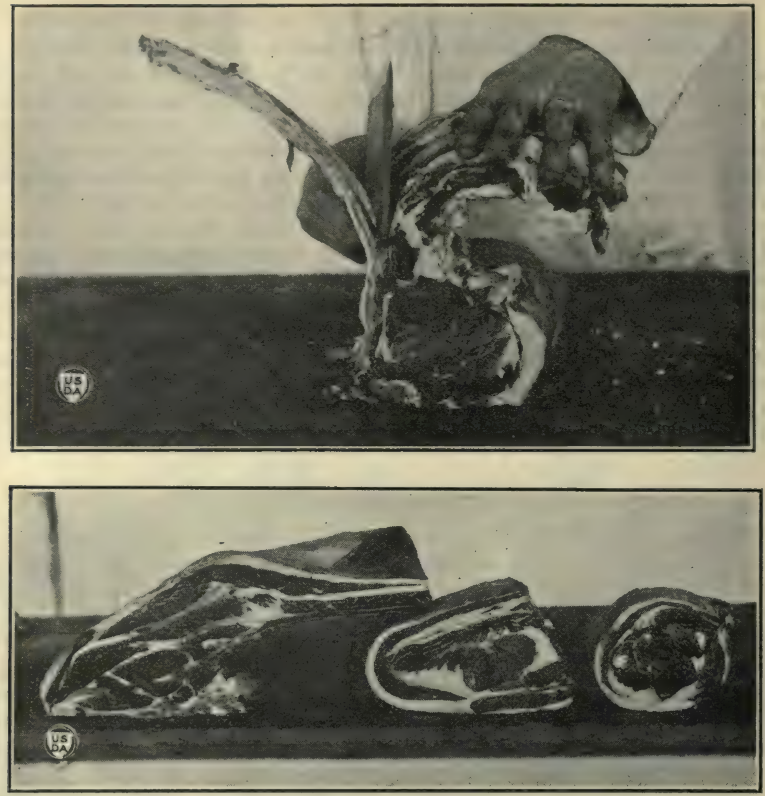

FIG. 46.—(Upper) preparing rolled roast. (Lower) standing rib roast (left); folded rib roast (center); boned rib roast (right).

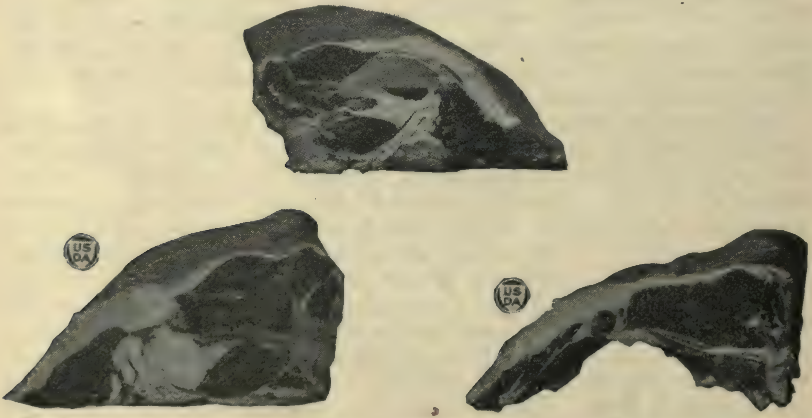

FIG. 47.—Loin cuts: Sirloin (center), porterhouse (left), club (right).

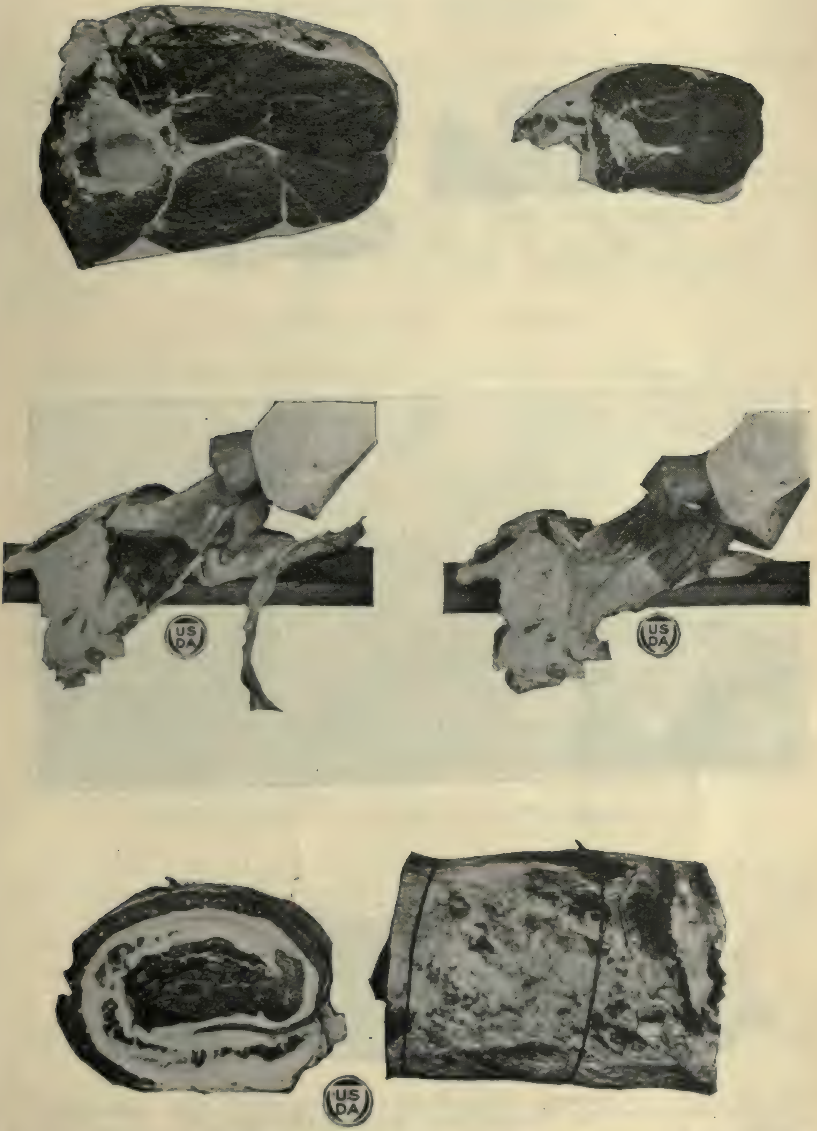

Fig. 48.—Upper left, round; upper right, rump. Center left, removing fell from flank; center right, removing flank steak; lower, rolled flank (2 views).

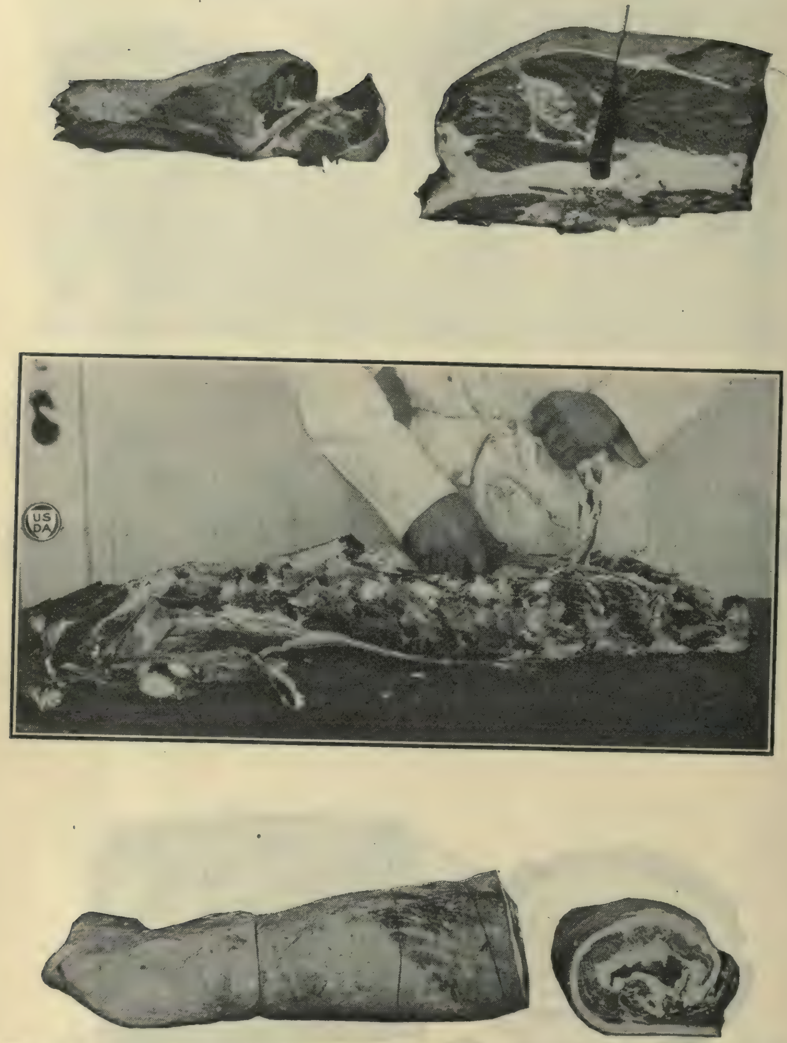

FIG. 49.—Upper left, removing cross-arm pot roast from chuck; upper right, chuck suitable for either roast or stew; center, removing ribs from plate; lower, rolled plate.

cooked. It should then be heated to a temperature of 250° F. for 45 minutes, or at 15 pounds' steam pressure.

HANDLING THE HIDE.[1]

Remove dirt, blood, and any pieces of flesh on the hide by scraping with the back of a butcher knife and by careful cutting. Allow the hide to lose its animal heat before applying salt. When the hide has cooled sufficiently, spread it, hair side down, being sure to straighten out all folds and laps. Sprinkle fresh, clean salt over the flesh side of the hide, using about 1 pound for every pound of hide. See that all parts of the flesh side receive a sprinkling of the salt. Be sure to use plenty of salt and rub it in well along the cut edges, head, neck, legs, wrinkles, and the heavy portions.

SLAUGHTERING CALVES.

Most veal is produced in this country from calves between 1 and 3 months old, weighing from 75 to 150 pounds.

Stun the calf before sticking it (as in killing cattle), but the blow need not be heavy. The work is made easier if the carcass is hoisted to a convenient height before skinning. Wash the hide and split the skin from head to tail, following the middle line of the belly. If the carcass is to be cut on the farm, the hide may be removed at once, as the carcass can be skinned more easily while it is still warm. Use a knife to start the skin, then "fist" off the hide. Remove the offal and split the breastbone and pelvis, as described for beef. In case the veal is to be shipped, the hide should be left on, to preserve the light color and prevent the carcass from drying out.

A plain-dressed calf carcass dries out more rapidly than a "caul-spread" carcass. The latter consists in removing the hide and spreading the caul over the hind quarters. The caul is the thin sheet of membrane extending from the stomach over the intestines.

SHIPPING FARM MEAT INTERSTATE.

There are Federal regulations which must be complied with before shipments of beef or other meat products can be made interstate. Copies of these regulations may be obtained upon request to the Bureau of Animal Industry, United States Department of Agriculture, Washington, D. C.

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[1] Detailed information in handling hides is given in Farmers' Bulletin 1055, "Country Hides and Skins: Skinning, Curing, and Marketing," a copy of which may be obtained upon request to the United States Department of Agriculture.

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FARMERS' BULLETIN No. 1416

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FATTENING BEEF CALVES

LIVESTOCK MARKETS during recent years have experienced a constantly growing demand for well-fattened beef animals weighing from 800 to 1,200 pounds. This has been due to the increasing demand by beef consumers for light-weight, high-grade cuts. Such a demand must necessarily be supplied by well-finished animals from 12 to 20 months old, carrying a large percentage of the blood of one of the early maturing beef breeds, usually that of the Hereford, Aberdeen-Angus, or Shorthorn. To distinguish them from animals of other beef classes, these yearlings are sometimes designated as baby beeves. The preparation for market of this class of beeves requires more skill than is necessary in the production of animals marketed at more mature ages, on account of their tendency to grow rather than to fatten.

This bulletin deals with various phases of the fattening of calves for market. It is a revision of and supersedes Farmers' Bulletin 811, "The Production of Baby Beef."

Washington, D. C. Issued June, 1924

FATTENING BEEF CALVES.

By SAM H. RAY,[1] *formerly of the Animal Husbandry Division, Bureau of Animal Industry.*

Revised by ARTHUR T. SEMPLE, *Animal Husbandman, Animal Husbandry Division.*

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MARKETING BEEF CATTLE AT AN EARLIER AGE.

THE TENDENCY to finish beef cattle for slaughter at earlier ages in the United States began about 40 years ago. Before that time grass was so plentiful, corn was so cheap, and marketing facilities were relatively so undeveloped that beef steers were kept on the range until they were from 4 to 5 years old, and then were finished on corn. Now most of the finished cattle go on the market for slaughter at from 1 to 3 years of age. This change has been made possible by breeding cattle of better quality which mature earlier. Beginning about 1880 many purebred beef cattle were imported, making possible the subsequent great improvement in western range cattle.

Formerly heavy cattle brought the highest price, but during recent years choice yearlings have sold as well as the best heavy cattle. In fact, the market for them has been more stable than for any other class of cattle. Recent increases in the retail prices of beef have greatly increased the demand for smaller cuts of beef and consequently for cattle finished at an earlier age.

To fatten yearlings successfully they must be placed on a fattening ration when they are weaned and kept on a full feed until they are ready for marketing.

COMPARING THE FATTENING OF CALVES AND MATURE CATTLE.

In a general way the advantages of feeding yearlings over heavy cattle are as follows:

The amount of feed required to make a pound of gain increases as the animal grows older. In other words, yearlings make from

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[1] Mr. Ray resigned April 16, 1917.

25 to 40 per cent more gain than mature cattle on the same quantity of feed.

On account of the higher price of beef, the consumer prefers the lighter cuts which the yearling carcass furnishes. A cut of proper thickness from a heavy carcass is too expensive for the average consumer.

Open heifers, when finished as yearlings weighing from 700 to 800 pounds, sell nearly as well as steers. Older heifers are discriminated against because they have more internal fat and a poorer external covering than steers, and because they are likely to be pregnant.

Yearlings can be carried longer than mature steers when unexpected circumstances arise, such as a bad market, a strike, or an embargo, as they will carry their "bloom" longer after they are ready to market.

It is not always advisable to try to fatten cattle as yearlings, for the following reasons:

Fattening calves and yearlings requires more attention and skill on the part of the men feeding them than is the case with mature cattle.

Calves of poor conformation, poor quality, and slow-maturing type will not fatten rapidly enough to make desirable carcasses as yearlings. Such calves should generally be carried about two years as stockers before they are fattened.

The total feed required to produce a fat 3-year-old steer may be made up of a much larger proportion of roughages than that required to produce a fat yearling. Mature cattle can eat coarser roughages and broken ear corn much better than young cattle.

Mature cattle may be fattened in a much shorter time than calves, as they have only to fatten, while calves grow as well as fatten.

HOW TO PROCURE CALVES TO BE FATTENED AS YEARLINGS.

The ideal way to produce fat yearlings consists in keeping a good herd of grade or purebred beef cows and a purebred beef bull of good individuality. Then one should teach the calves to eat grain before they are weaned in order that they can be weaned with only a slight interruption of their growth and a slight loss of milk fat. The slighter this interruption and loss of fat the less feed will be required to put them in the desired condition and the sooner they can be finished for market.

If it is not practicable to keep a breeding herd, one must buy weanling calves suitable for fattening as yearlings. While such calves may sometimes be procured from the Corn Belt, the Cotton Belt, and the Appalachian region, the principal source of such calves is the western ranges. When calves are purchased precautions must be taken to see that they are uniform, have not been stunted, and are free from disease. If they are shipped by rail, such hardships as long hauls, delays, and lack of good feed and water should be avoided as much as possible. The cars in which they are shipped should be thoroughly cleaned and disinfected.

As most calves are dropped in the spring and weaned in the fall, the fall is the best time to get a good selection. One may purchase them at the public stockyards, on the ranches where they are produced, or at public auctions such as have been held recently at central points in the Corn Belt by producers' associations of the Southwest. Such associations are able to furnish uniform lots of calves by pooling and grading the contributions of their members. Generally the public stockyards offer the largest and most continuous supply of calves conveniently concentrated.

TYPE OF CALVES SUITABLE FOR FATTENING.

The wide, deep-bodied, thick-fleshed calf with short legs and an abundance of quality as indicated by fineness of hair, texture of skin, smoothness of flesh, and general refinement about the head and other parts of the body is the type best suited for making prime baby beef. Uniformity in size, weight, and color should not be overlooked, because such factors are an advantage in marketing.

By all means calves to be fattened as yearlings should not be allowed to lose their milk fat. The calf lacking in early maturing qualities will use most of its feed for growth instead of fattening. Quality and finish are very desirable in fat yearlings. Half-finished yearlings do not usually bring enough on the market to make their production profitable.

BREEDS SUITABLE FOR FATTENING AS YEARLINGS.

All the principal beef breeds of the United States, such as the Shorthorn, Hereford, Aberdeen-Angus, and Galloway, are suitable for producing calves to be fattened as yearlings. Each of the breeds mentioned has its points of excellence, and the matter of making a selection, while depending somewhat on local conditions, rests largely upon the personal preference of the feeder. The problem of selecting the individual animals after the breed has been chosen is of much greater importance than the selection of the breed itself.

Farmers' Bulletin 612, "Breeds of Beef Cattle," discusses the characteristics of the different beef breeds. It may be obtained without charge on application to the Department of Agriculture, Washington, D. C.

IMPORTANCE OF GOOD COWS AND BULLS.

For producing the best grade of calves to be fattened as yearlings, good purebred bulls and very high-grade beef cows should be used. (See figs. 1, 2, and 3.) If the bulls are unusually good half-breds or three-quarter breds, and the cows are sired by purebreds, good calves may be produced for this purpose. In many herds where purebred bulls have been used for five or six generations or more the cows are practically purebred.

Quite as important as breeding is the individuality of the cow. She should be selected to meet as nearly as possible the ideal beef conformation, consisting of short legs, deep, wide, symmetrical body, straight top and bottom lines, well-filled flanks, well-developed udder, thick quarters, strong back, large feeding capacity, full heart girth, well-covered shoulders, short neck, short, broad head, large muzzle, and quiet disposition. She should possess good quality as indicated by fine hair, a pliable hide of medium thickness, clean-cut, dense, and medium-sized bones, thick, firm flesh, and general smoothness or lack of rolls and patches on the sides and around the tailhead. Freedom from disease, parasites, and organic troubles, is a very essential requirement. The cows should be of uniform breeding and of colors representative of the beef breeds.[2] They should be of good size, weighing at least 900 pounds in medium condition. A very important factor which, like milk production, can not be determined conclusively by looking at a cow, is that of early maturity. A thick, low-set body and fine quality are indications of early maturity. The cow should give plenty of milk to keep the calf fat and growing until it is about 6 months old.

As a general rule, shortcomings in any one or all of the desired points in the cows may be offset to some extent by breeding them to a very good bull. Some bulls have prepotency enough to stamp their own excellence of form and quality upon their calves even though the cows are inferior. As one can not tell what a bull is worth as a breeder except by his offspring, it is best to select a bull coming from a line of ancestry which has been noted for its excellence of form, quality, milk-producing ability, and early maturity, for such a bull is likely to be a producer of animals of like kind. This, together with individual excellence in the bull, is the only standard we have for forecasting the type of calves which an untried bull will get.

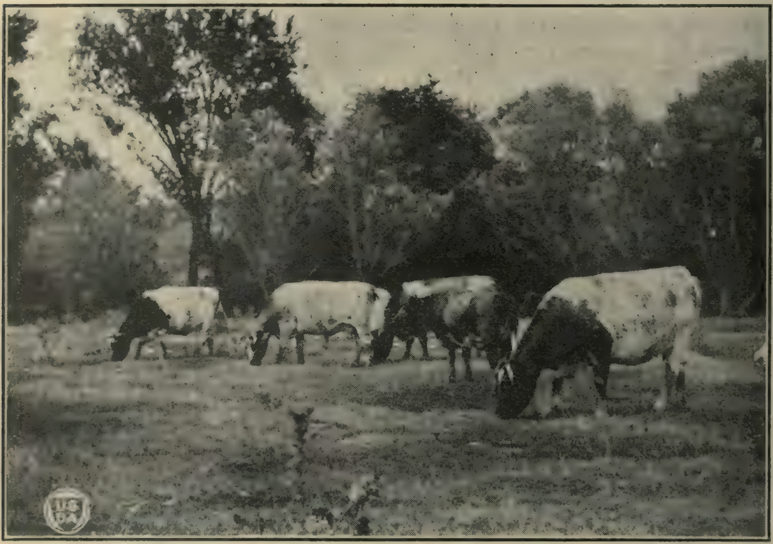

FIG. 1.—Cows of excellent quality and conformation for raising beef calves. While there is more shade here than necessary, it is very valuable in a pasture.

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[2] If purebred Aberdeen-Angus or Galloway bulls are used, the calves, in general, will be polled and black, only slightly, if at all, marked with white. A considerable number of blue roans and white-faced blacks may be expected, however, from matings of such bulls with Shorthorn and Hereford females, respectively. Purebred Hereford bulls may be expected to transmit their white faces but not their red color with any regularity except from matings with red cows. White Shorthorn bulls produce in general roans of some sort—blue roans, red roans, yellow roans, etc. Red and roan Shorthorn bulls may produce almost any color, depending on the color of the cow and her ancestry.

Above all, in selecting a bull one should procure an individual of good beef form and with a strong tendency toward earliness of maturity, as success in raising and feeding baby beeves will depend to a very large extent upon the bull's ability to transmit these characteristics to his calves.

MANAGEMENT OF THE FARM BREEDING HERD.

Unless the farmer has some satisfactory method of marketing small lots of cattle, he should keep cows enough to produce at least one carload of baby beeves. A 36-foot car holds approximately 27 calves averaging 950 pounds, or 25 1,050-pound calves. As the farmer should get at least an 85 per cent calf crop, approximately 32 cows would be necessary to produce a carload of fat yearlings.

Feeders who have calves enough for two carloads have an advantage in that the animals can be graded, the better ones being placed in one car and the poorer ones in another; or, if the calves do not finish uniformly, one carload may be shipped, while the other one is held until the animals are finished.

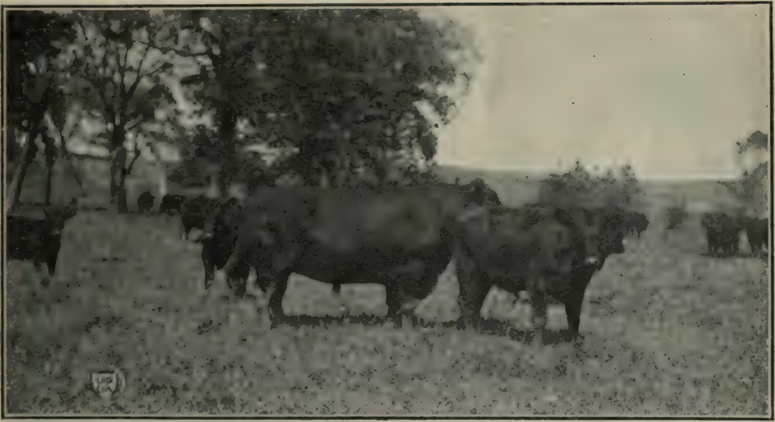

FIG. 2.—An Aberdeen-Angus bull of excellent type for siring early maturing calves. Note the luxuriant growth of grass. A creek running through this pasture furnishes an abundance of fresh water.

As uniformity in size and weight are important factors in producing fat yearlings, it is desirable that all the cows should calve within as short a period of time as possible. The average period of gestation for the cow is 283 days, or about 9½ months. To calve in April the cows should be bred during the latter part of June and up to the latter part of July. If it is desired to have the calves dropped in October the cows should be bred during the latter part of December or the first part of January. The bull should be kept separate from the cows until the breeding season arrives. Every effort should then be made to get all the cows in calf during six weeks or two months, or in less time if possible. A cow generally comes in heat at intervals of 21 days, and those that are not in calf after three services to a fertile bull should be disposed of. Farmers' Bulletins 1073 and 1395 take up the problems of, respectively, farm and range management of beef-breeding herds.

FALL OR SPRING CALVES.

In recent years a considerable number of farmers have adopted the plan of having their calves dropped in the fall. The advantages of this system are:

Calves born during the fall are not bothered by flies. They can be castrated and dehorned without danger from screw worms.

The fall calves fit in with pastures better than spring calves. As the young calves need no grass until weaning time, they can nurse their dams during the winter months and go directly on pasture when weaned in the spring. At the end of the summer spent on pasture supplemented with grain they are ready to go into the dry lot for finishing. On the other hand, the spring calves on full feed during the winter should not be turned on grass. With moderate winter feeding they may be fattened on good grass and a full feed of concentrates early in summer.

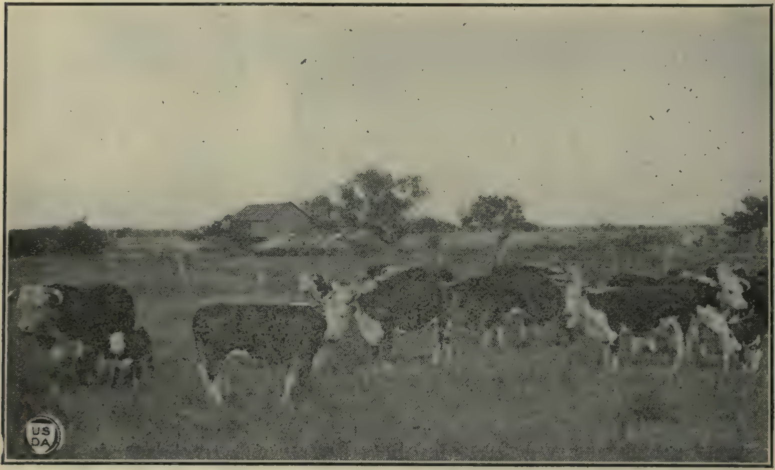

FIG. 3.—A good lot of grade Hereford cows, suitable for producing calves which will fatten as yearlings. Note the quality and beefiness of the bull.

The farmer who sells milk may derive greater profit when his cows freshen in the fall, as milk markets are better then.

Finishing calves in the fall and early part of the winter interferes less with the other farm work than in the spring and early part of summer.

The disadvantages of fall calving are:

In extremely cold climates calves born late in the fall suffer from the cold, unless warm barns are available.

As more feed is necessary to maintain the cows when they are nursing calves during the winter, the expense of keeping the herd is increased, since pastures are not always available.

Unless the farmer buys cows bred to calve in the fall he can not make the change from spring to fall calving without losing six months of service from the cows.

Those breeders who have tried the fall-calving plan seem to favor it highly, but it does not work to advantage under all conditions.

FEEDING THE CALF FROM BIRTH TO WEANING TIME.

Unless the cows in the herd are exceptional milkers, calves intended for fat yearlings should be started on corn, kafir, milo, barley, wheat, or oats when from 4 to 6 weeks old. Nothing so stimulates growth and early maturity as milk sucked fresh from the dam, but in all cases calves should be fed liberally on grain for at least one month before weaning time.

Every effort should be made to get the calves through the weaning period without loss of their milk fat. (See fig. 4.) The grain ration should be increased so as to permit as little change in their rate of growth and fattening as possible. Some feeders build "creeps" in the pastures or lots so that the calves can get their grain without disturbance from the cows. Creeps consist of small pens with openings which permit only the calves to enter. These openings may have rollers on each side to prevent bruising the calves.

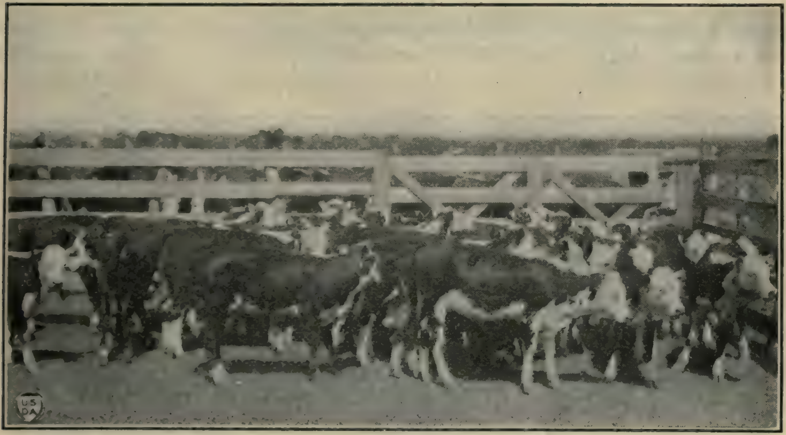

FIG. 4.—Weanling Hereford calves carrying their calf fat, of such good quality and breeding that they will make choice beef, if properly fed and cared for, at about 12 months of age.

Calves from heavy-milking cows should be weaned gradually. If they are running with the cows the weaning should be begun by keeping them up and allowing them to suck only twice each day for five or six days, after which they should be allowed to suck only once a day for a similar period. Then one day's sucking may be omitted, and later two days. Thus the entire weaning takes from 10 to 15 days. The calves of cows giving little milk should be weaned abruptly by separating them as far as practicable.

Fall calves should not be weaned until after the cows and calves are on grass. Spring calves should either be kept on grass after weaning in the fall or be given some succulent feed, such as silage. It is advisable to provide them with winter pastures, such as wheat, oats, rye, or barley, when soil and climatic conditions permit.

DEHORNING, CASTRATION, AND VACCINATION.

Spring calves should be castrated as soon as convenient, unless there is danger of screw-worm infestation. Dehorning should be done in the fall after danger of screw-worm infestation has passed. Good results are usually obtained, however, if the horns are sawed or clipped off when the calf is about 6 months old. Usually about one-quarter of an inch of hair and skin is removed with the horn, although this is not so important with calves which are not to be carried to maturity. During fly time, pine tar should be used on the wounds to prevent infestation with screw worms or maggots. Calves raised under farm conditions may be successfully dehorned by the application of caustic potash before they reach the age of 10 days.

Losses from castration generally occur through improper wound drainage. In making the cut through which the testicles are to be removed, the scrotum should be grasped firmly and a free slit made with a sharp knife over each testicle from one end of the scrotum to the other through the enveloping membranes. The testicles are then forced one at a time through the openings. The cords may be severed either by scraping with a knife or by using an emasculator or écraseur. Detailed information on dehorning and castrating is given in Farmers' Bulletin 949.

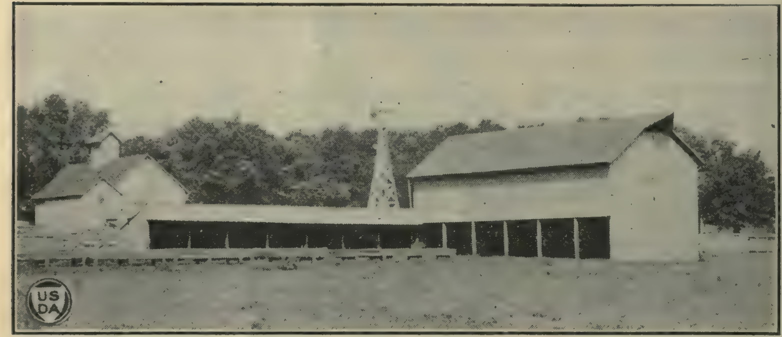

FIG. 5.—A good barn for feeding calves, with a large mow, an open shed, and bunks in the open for feeding grain. The hay is fed under cover.

In localities where blackleg is prevalent all calves should be vaccinated. If the powder vaccine is used, they should be revaccinated before the next blackleg season. Aggressin and filtrate apparently give the longest immunity, which may last for 18 months or longer. Vaccination against hemorrhagic septicemia is advisable, especially when the calves have been shipped through public stockyards.

EQUIPMENT AND SHELTER.

To fatten calves an expensive outlay is not necessary. A small, well-fenced lot, a well-constructed shed with a good roof, open on the south, with feed troughs or bunks, hayracks, and free access to a supply of pure water are practically all that is required. Storage and hauling facilities for feed are usually maintained on a farm whether cattle are fed or not. Twenty square feet of floor space per calf is adequate for shelter, while two or three times as much lot space is usually allowed. If the lot is likely to become very muddy it should be paved or roofed over unless an abundance of bedding can be put down cheaply to keep the calves dry and clean and to save liquid manure. They should have a dry bed at night. They need protection against cold winds and snow in the North and cold rains in the South. Figure 5 shows good equipment for feeding calves. Farmers' Bulletin 1350 illustrates plans for a cattle-feeding shed.

FEEDING THE CALF FROM WEANING TIME TO MARKET.

Calves that are born in the spring are fed and managed differently from those dropped in the fall. To aid the feeder in handling calves under these different conditions Table 1 is given.

TABLE 1.—*A schedule of management and feeding for finishing spring and fall calves at 15 months of age.*

Spring calves.			Fall calves.		
Month.	Management.	Feeding.[1]	Month.	Management.	Feeding.[1]
March	Dropped [2]	Suckle dam.	October	Born [2] on pasture.	Suckle dam.
April	Castrate	Teach to eat grain.	November	Castrate	Teach to eat grain and hay.
May	On pasture	Shelled corn ½.	December	Dry lot	Corn ½; oats ½; hay ½.
June	do	Shelled corn 1.	January	do	Corn 1; oats ½; hay 1.
July	do	Shelled corn 2.	February	do	Corn 2; oats ½; hay 1½.
August	do	Shelled corn 3.	March	do	Corn 3; oats ½; hay 2.
September	do	Shelled corn 4.	April	do	Corn 4; oats ½; hay 3.
October	Wean	Shelled corn 5.	May	On pasture	Corn 5.
November	Dry lot	Shelled corn 6. Oil meal [3] 1. Silage 8. Clover hay 3.	June	Wean	Corn 6.
December	do	Shelled corn 7. Oil meal 1¼. Silage 10. Clover hay 3.	July	do	Corn 7.
January	do	Shelled corn 8. Oil meal 1½. Silage 12. Clover hay 3.	August	do	Corn 8.
February	do	Shelled corn 9. Oil meal 1¾. Silage 10. Clover hay 3.	September	do	Corn 9
March	do	Shelled corn 10. Oil meal 2. Silage 9. Clover hay 3.	October	Dry lot	Corn 10. Oil meal [3] 2. Silage 10. Clover hay 3.
April	do	Shelled corn 12. Oil meal 2¼. Silage 9. Clover hay 2.	November	do	Corn 12. Oil meal 2¼. Silage 9. Clover hay 2.
May	do	Shelled corn 14. Oil meal 2½. Silage 8. Clover hay 2.	December	do	Corn 15. Oil meal 2½. Silage 8. Clover hay 2.

[1] The rations indicated are in pounds of feed per calf per day. It is not expected that the calves will eat exactly these quantities of feed in these exact proportions.

[2] Dehorn within 10 days with caustic potash.

[3] Oil meal may be linseed meal, soy-bean meal, cottonseed meal, or other meals similarly rich in protein.

The rations indicated in the table consist of corn, oil meal, silage, and clover hay. Other feeds may be substituted. Barley, milo, kafir, and similar grains may be used in the place of the corn, but slightly larger quantities should be fed. Alfalfa or other legume hays may be used in place of clover hay. Other silages or root crops may be used instead of corn silage.

When available, oat straw should be kept before the calves on account of its slightly laxative and alterative effect. It has been found at experiment stations that rations consisting of a grain, some kind of oil meal, a succulent feed, and a legume hay generally produce the best results. Some feeders, however, finish calves on simpler rations. A ration of corn and alfalfa hay gives very good results. A lot of yearlings being finished on corn, oil meal, and clover hay is shown in Figure 6.

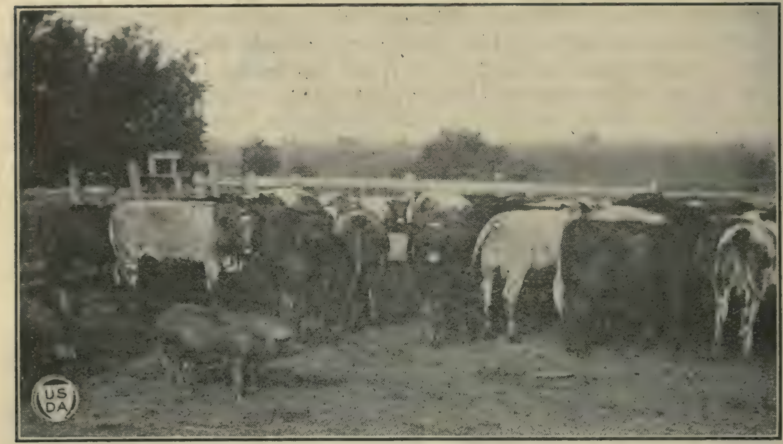

FIG. 6.—Shorthorn yearlings being finished on corn, linseed meal, and clover hay. Hogs following cattle fed such a ration make desirable gains.

Average daily rations, per 1,000 pounds live weight, suitable for the last six months of the feeding period are as follows:

1.

	Pounds.
Corn	15
Cottonseed meal	2.5
Clover hay	3
Corn silage	20

2.

Corn-and-cob meal	18
Linseed meal	3
Clover hay	3
Corn silage	10
Oat straw, unlimited.	

3.

Corn	18
Cottonseed meal	2
Alfalfa hay	8

4.

Barley	20
Beets or roots	10
Alfalfa hay	5
Oat straw, unlimited.	

5.

	Pounds.
Kafir or milo	16
Cottonseed meal	2
Kafir or milo silage	25
Kafir or milo stover, unlimited.	

6.

Corn	14
Oats	5
Clover hay	5
Corn silage	10

7.

Corn	20
Alfalfa hay	10

8.

Corn	12
Molasses	6
Cottonseed meal	2
Lespedeza hay	10

These rations are average for the main feeding period. A small quantity of grain is fed at the start, and the quantity is very gradually increased throughout the entire feeding period. Corn may be increased at the rate of about 1 pound a month, or more if the calves will take it. Cottonseed meal or linseed meal may be increased from one-fourth of a pound a day to 2 pounds during the first six or eight weeks. If silage is fed, a light ration is given at first, which is increased as rapidly as the calves will take it until the last six weeks of the feeding period, when it is decreased so that the grain ration may be increased.

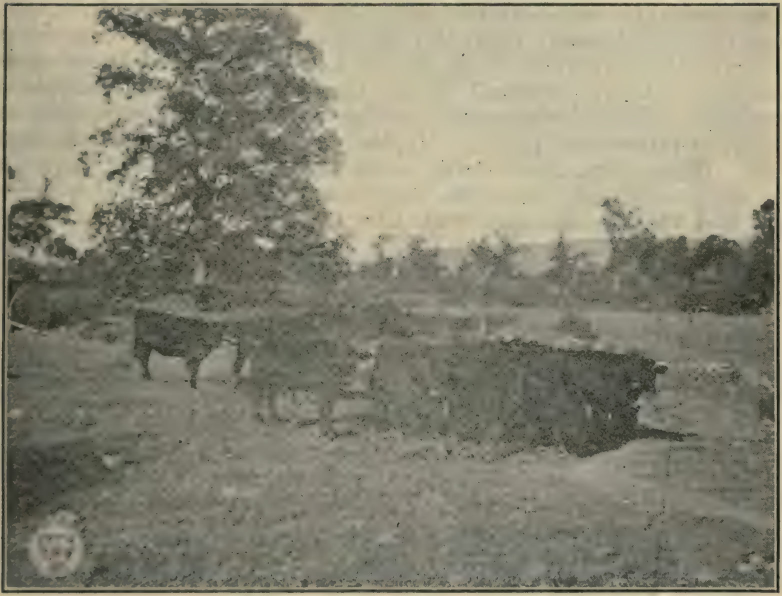

Fig. 7.—Good Aberdeen-Angus yearlings on bluegrass pasture to be fattened in dry lot and marketed as short 2-year-olds.

MANAGEMENT OF CALVES ON PASTURE.

Good pasture may replace the roughage in the calves' ration. (See fig. 7.) As a rule the calves should be given all the grain they will eat while on pasture. It is seldom advisable to carry them through the entire finishing period on grass, as a better finish is obtained when they are dry fed during the latter portion of the period. While it is never advisable to change cattle from dry lot to pasture when on full feed, it is safe to change from pasture to dry-lot feeding.

When the pasture is very good, calves may not consume grain enough for the best results. In such cases it may be better to keep them off the grass a part of each day. In sections where winter pastures can be grown, the feeder should make use of such pastures, as they furnish roughage economically and make the calves more thrifty.

HOGS FOLLOWING CALVES.

Hogs should always follow calves to utilize grain wasted from the bunks and the undigested grain in the droppings. From 1 to 2 pounds of pork should be obtained from each bushel of shelled corn fed to calves. Thrifty shotes weighing from 40 to 70 pounds are best for this purpose. Heavy hogs, when fat, are not active enough, and small pigs are unsatisfactory because they are likely to be injured by the calves.

The number of shotes to be used depends on the kind and quantity of grain fed and whether it is ground or fed whole. Ordinarily there should be one shote for every two calves. Some grain in addition to that obtained from the droppings may be fed in order to finish the hogs in from 90 to 100 days, so that another lot of shotes can be put in and finished by the time the calves are ready to be marketed. Some feeders prefer to take out the shotes when they are ready to fatten and put in with the calves a new bunch of feeder pigs. When extra grain is fed to the hogs it should be given before the calves are fed. Separate watering facilities, sleeping quarters, and feed yard should be provided for the hogs.

MARKETING.

During the last two or three days of feeding, laxative feeds, such as alfalfa, linseed meal, and succulent feeds should be gradually replaced by oats and grass hay or similar dry and nonlaxative feeds. The calves should be handled as quietly and carefully as possible in moving them to market. Cattle ship better if the car contains the proper number. Either too few or too many in a car may result in losses. The car should be bedded, with either sand or dry bedding enough to prevent slipping. Freight rates generally apply to a minimum weight per car; that is, the amount charged for freight is the same, even though the car contains less than the minimum weight. If the car is loaded above its scheduled minimum weight, however, freight charges are levied on the excess weight.

Table 2 shows the approximate number of cattle and calves which can be shipped in cars of different lengths.

TABLE 2.—*Approximate number of cattle and calves that can be shipped in railroad cars of various lengths.*

Approximate weight of animals.	36-foot car.	38-foot car.	40-foot car.
400 pounds	50	52	55
600 pounds	40	42	45
800 pounds	30	32	34
950 pounds	27	28	30
1,050 pounds	25	26	27
1,150 pounds	22	23	24
1,200 pounds	20	22	23

In many States there are county or community livestock-shipping associations, which are a considerable advantage to the shipper with less than a carload.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

May 15, 1924.

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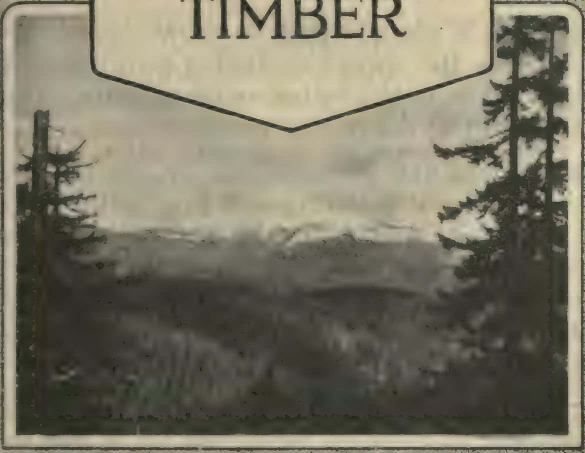
U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1417

IDLE LAND AND COSTLY TIMBER



A REAL TIMBER SHORTAGE already exists in the United States. It is due to idle forest lands. Full use of their growing power is the only way to make ends meet, on a basis of sufficient timber supplies.

Idle forest lands are in themselves harmful, since they mean lowered wealth production; and the depressing effect of this falls most heavily on the rural communities where such lands abound.

Intensive forest culture applied to the equivalent of our entire present forest area is essential to meet the country's permanent timber requirements. Agricultural demands will not require the cutting down of this area for cultivation.

Although it already pays to grow forests in various regions, the spread of timber-growing must be accelerated by public action or the remedy will come too late to meet the public needs.

The urgent first steps called for are the protection of all forest lands against fire, better tax laws applicable to growing forests, more publicly owned forests, public aid to tree planting, nation-wide education in forestry, and research to develop improved methods of growing and using timber.

Washington, D. C. Issued April, 1924

IDLE LAND AND COSTLY TIMBER.

By W. B. GREELEY, *Forester, Forest Service.*

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WHAT HAS BECOME OF OUR TIMBER?

TO THE VOYAGEURS and colonists of the seventeenth century, America appeared a vast, unbroken forest. Even after the full extent of the prairies and great plains and western deserts became known, geographers found that over 820 million acres, or nearly half of our land area, originally bore commercial timber. For two and a half centuries these forests were cleared for cultivation or cut for lumber in the universal belief that the supply of timber was inexhaustible. But to-day a shortage of wood, growing more acute every year, thrusts itself to the front as one of the vital economic problems which the present generation of Americans must solve.

A map (Fig. 1) showing the timber which is left tells the story. About 30 per cent of the original virgin stand is still uncut and contains probably 1,600 billion board feet of merchantable saw timber. To this may be added possibly 600 billion feet in the form of leavings or new growth on the old cuttings. The most important fact, however, is that 75 per cent of the remaining virgin timber and over 60 per cent of all the timber we have is west of the Great Plains. In all except the States of the far West and the far South, the exhaustion of timber as a national resource has largely run its course.

WHY ARE LUMBER PRICES RISING?

The needs of the American consumer of wood are not answered by saying that certain parts of the country contain enough timber to supply the present rate of cutting for 30 or 40 years longer.

It may be said with almost equal weight that there are vast forests in Siberia and South America. Every user of lumber knows that lumber cost has increased enormously during the last 25 years. The retail price of construction lumber has doubled within little more than a single decade; during the last 80 years the price of lumber has advanced three and a half times as fast as the average price of all staple commodities. The cost of lumber has already become so high that the per capita consumption has decreased nearly 40 per cent. Notwithstanding the substitution of other materials, there is to-day a large unsatisfied demand for wood in the Eastern and Central States, where the great bulk of our forest products is consumed. This is evidenced by the shortage of a million homes, by the construction of smaller and poorer dwellings, by the reduced use of needed lumber for farm improvements. For two-thirds of the American people a "timber famine" is not a distant or hypothetical thing. It is here.

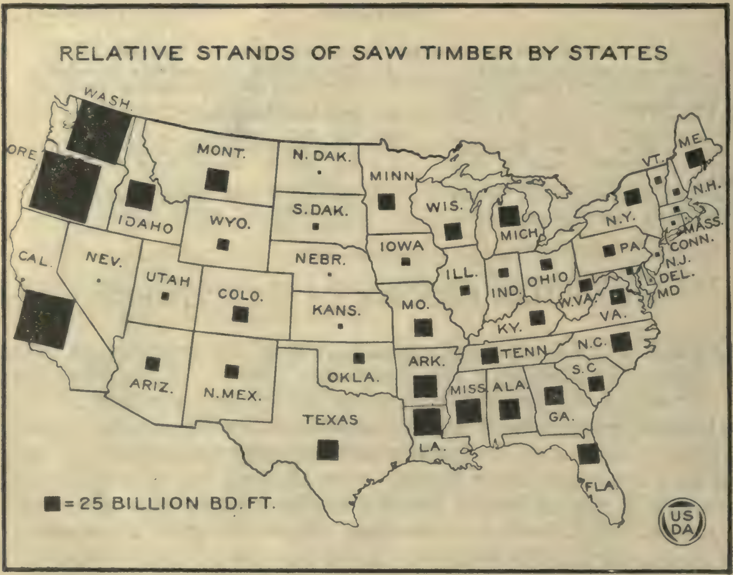

FIG. 1.—Most of our standing timber is in the South and West. The Middle Western and Northeastern States, though our largest consumers of timber, are far from producing the timber they use.

Looking beyond fluctuating markets and war aftermaths, the fundamental reason for the advancing price of lumber is the steady rise in the cost of transporting it. The constant migration of the sawmills from one virgin forest to another has carried them farther and farther away from the average consumer of their products. In 1920, 28 States produced less lumber than they consumed, and only 9 States, all in the South or West, cut a substantial quantity of lumber in excess of their own requirements. So far apart have the main lumber consuming and lumber producing centers become that our annual freight bill on lumber has reached $250,000,000. Many populous States now pay out from $10,000,000 to $28,000,000 annually to import the lumber which they require.

It is a far cry back to the days when $2 per thousand feet paid the freight on lumber shipped down the Hudson River to New York, or down the Susquehanna to Philadelphia. Panama freighters now bring yearly hundreds of millions of feet of everyday construction lumber 6,500 miles from the Pacific coast to the northern Atlantic ports. (Fig. 2.) Their charter rate of $16 per thousand feet, plus $2 or $3 more for inland distribution by rail, is setting a level of lumber costs still higher than any which has previously existed. And, inevitably, higher distributing costs and profits pyramid upon each increase in lumber freights. Inevitably, as the source of timber becomes more contracted and more distant, as the competitive marketing of lumber from different producing regions becomes more restricted, its cost to the consumer goes up. Not quantity but availability is the true measure of timber exhaustion. Lumber is steadily becoming more dear because the timber supply remaining is less and less available to the average consumer.

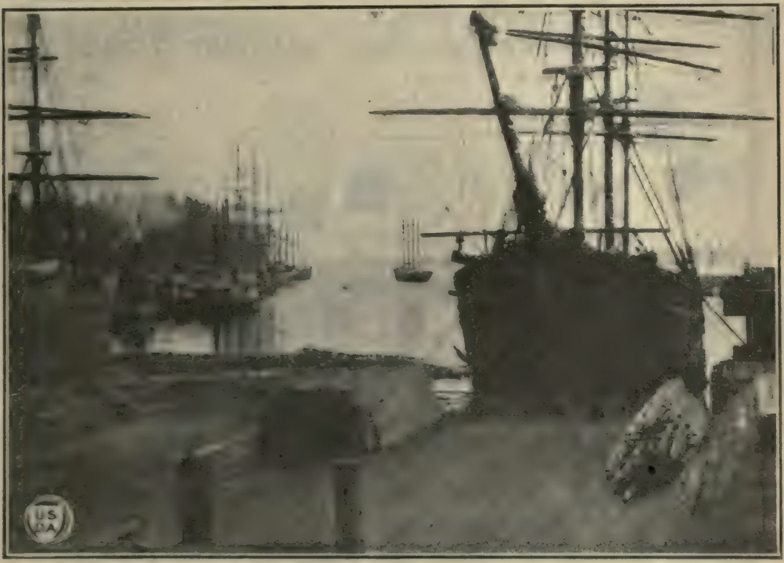

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Fig. 2.—Panama freighters now bring hundreds of millions of feet of everyday construction lumber yearly 6,500 miles from the Pacific coast to the northern Atlantic ports.

WHAT HAS BECOME OF OUR TIMBERED LAND?

Out of every 10 acres of the virgin forest which Columbus discovered, 4¼ acres have passed under the plow; 4 acres more have been cut over but still lie untilled—an aggregate area over 10 times the State of New York. Of the 4 acres, 3 contain culled timber, second-growth timber, or young trees, often scattered and incomplete to be sure, but enough to represent some small degree of forest replacement. The fourth acre is the idle acre, the acre which has been so denuded and burnt that it is producing nothing. The idle quarter of our cut-over forest lands represents 81,000,000 acres, mainly in the Eastern States and much of it within a stone's throw of great lumber-using centers like Boston, Pittsburgh, and Detroit.

While most of our virgin timber is gone, most of our forest land remains. And as the map in Figure 3 shows, the bulk of it lies east of the Mississippi River, in the very States having the densest population and the most highly developed wood-using industries. Even New York and Pennsylvania contain 40 per cent of forest land. Most of the Southern States have 50 per cent or more. In New Hampshire the amount is 60 per cent, and in Maine it exceeds 75 per cent. In the condition of these forest lands of the Eastern States lies the root of the problem. Lumber has become dear to the eastern consumer, not because virgin forests were freely cut, but because the land which the logger left behind is so largely land without a crop.

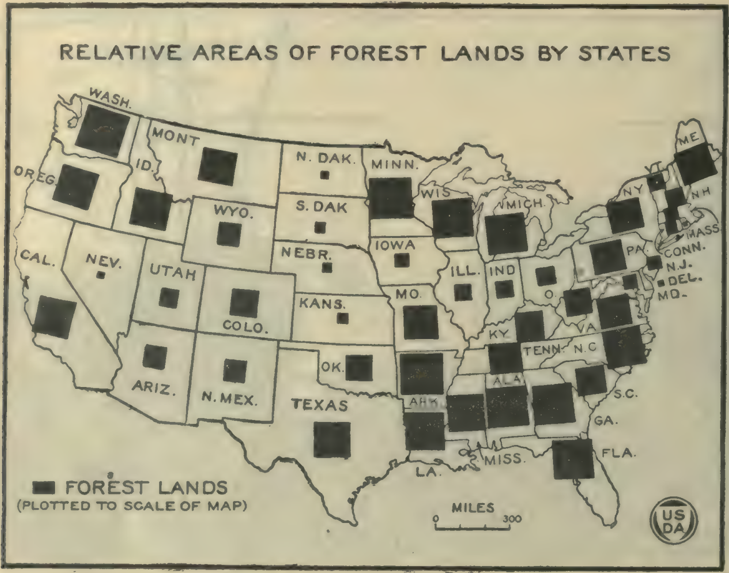

FIG. 3.—Though the original forests have largely disappeared, we still have plenty of forest land, if rightly used, to grow the timber we need; and the most of this land is in the East, where timber is most needed.

The idea still prevails that much more forest land will pass into tillage. While this is true in certain regions, like the southern river bottoms, it is more than doubtful when our forest areas are considered as a whole. The main increases in improved farm land during the last 10 years came from nonforested regions. Furthermore, the tide of cultivation ebbs as well as flows. The acreage of idle lands in many Eastern States has been swelled by abandoned farms. The last census showed that 20 States had lost in cultivated land, and these losses were mostly within their original forest areas, New England now has less farm land by 13 per cent than at the time of the Civil War.

Our remaining forests of all sorts are being cut at the rate of about 10,000,000 acres a year. A million acres are stumped and put under the plow each year; but nearly an equal area of old plow land, at one point or another, reverts each year to pine seedlings, brush, or barrens. Many a piece of old New England mow land is now a white-pine lot. Many a former cotton plantation is now in "old-field" pine. However the pendulum may swing from year to year, in the long run timber appears to be the only practicable crop on not far from one-fourth of the soil of the United States.

WHY IS IDLE LAND A MENACE?

Aside from the loss which falls upon the every-day user of lumber when he is compelled to import his requirements from distant sources instead of obtaining them near at hand, practically every forest region in the United States is experiencing to-day the local effects of idle or half-productive land. These effects are the more disastrous in the degree that the successful farm can not follow the logging camp. First the sawmills and then the secondary wood-using plants move out, taking most of the industrial population with them. Such farms as have been established lose their local markets. Towns pass into decadence or disappear altogether.

A forest town in Pennsylvania grew up about 1890 around a sawmill and a large tannery. In its prime it contained a hundred houses, with stores, town hall, a church, and a school. With the exhaustion of the surrounding timber the tannery moved out, and the sawmill was dismantled after a life of 30 years. The town site, with the houses, stores, and public buildings, was sold for $5,000. It is to-day a deserted village with only the State forest ranger left.

A Michigan township had 177 people in 1890. During the next 20 years its extensive pine forests were cut and manufactured at a thriving town with several sawmills. In 1900 it had 1,927 inhabitants; in 1920, 568. When the pine was gone, the only railroad was pulled up. Another Michigan township had a population of 2,042 in 1900, supported by a hardwood chemical factory and a smelting plant for charcoal and iron. Both plants closed when the hardwood timber was exhausted, and in 1920 the population had dwindled to 780.

These are but examples of what has happened at many points in the northern Lake States, the Pennsylvania Alleghenies, the mountains of West Virginia, and the southern pineries. Loss of industry, depopulation, and the tearing up of railroads have followed in the train of forest destruction and the idleness of land. Often indeed sawdust piles and clusters of rotting buildings are all that remain. Taxable values shrink enormously and the heavy tax burdens imposed upon the property left are inadequate to support community needs. Often indeed large areas of over-taxed logged-off land revert to the State. Isolation and impoverishment overtake the folk who remain, and social degeneracy is not far behind.

To many rural communities the idleness of this forest land means economic and social bankruptcy. In every region where the commercial cutting of timber for any class of products is still active, the acreage of cut-over forest land is gaining rapidly over the rate of clearing and settlement. In many regions the area of denuded and idle forest land is piling up each year by the hundreds of thousands of acres. Wholly aside from the loss of unreplaced forests, the aggregate of local depopulation and bankruptcy is a menace to national strength that can no longer be ignored.

Forestdale, Vt., is an example of another sort of forest community. It has had a wood-turning factory for 75 years. Instead of moving out, this institution has increased in size and in the variety of its products and now employs 200 workers. Eight thousand acres of forest land, more and more carefully managed, insures a perpetual supply of raw material. Many of the employees own their own homes and the labor turnover is less than 5 per cent a year. The continuous use of forest land insures a permanency of industry, of population, and of community life. It is essential, where the land is not better suited for other purposes, to the kind of rural community and the type of rural citizenship of which the United States stands in need.

HOW MUCH TIMBER DO WE NEED?

The United States leads the nations of the earth in the use of wood. We consume nearly half of the world's cut of lumber and two-fifths of all the forest products which it produces. The quantity, variety, and cheapness of our timber have led to its use in our homes, industries, and commerce to a degree that is without parallel in human history.

Ninety-eight per cent of our rural dwellings and from 59 to 98 per cent of our urban dwellings, varying in the different States, are still built of wood. From 25 to 28 billion board feet of lumber are used annually in building and construction, the farmers being the largest consumers and 9 billion shingles are laid annually in roofing these homes and other structures. Another 6 billion feet of lumber are manufactured yearly into crates and boxes to carry our commerce. Our railroads normally require from 100 to 125 million wooden ties annually. Our mining industry could not live without timber, and consumes nearly 300 million cubic feet of stulls and lagging every year. A hundred million cords of fuel are cut annually from our forests and woodlots. To support a per capita consumption of paper which is double that of any other nation, we cut 5 million cords of pulpwood from our forests every year, and still import from Canada and other foreign sources over half of our paper or paper-making materials.

And so on, down a long and constantly growing list. It is seldom realized how much of our timber goes into industrial use—for the manufacture of furniture, sash and doors, automobiles, agricultural implements, cooperage, and so forth. There are 53 categories of manufacturers, down to tobacco pipes, which depend upon wood. They include many of America's most distinctive and most boasted industries. They utilize nearly half of our total cut of large timber, more than similar industries consume in the rest of the world combined. All told, we take nearly 22½ billion cubic feet of wood from our forests annually. This is divided almost equally between timber of saw-log size and the smaller products, but is equivalent roughly to 53 billion board feet.

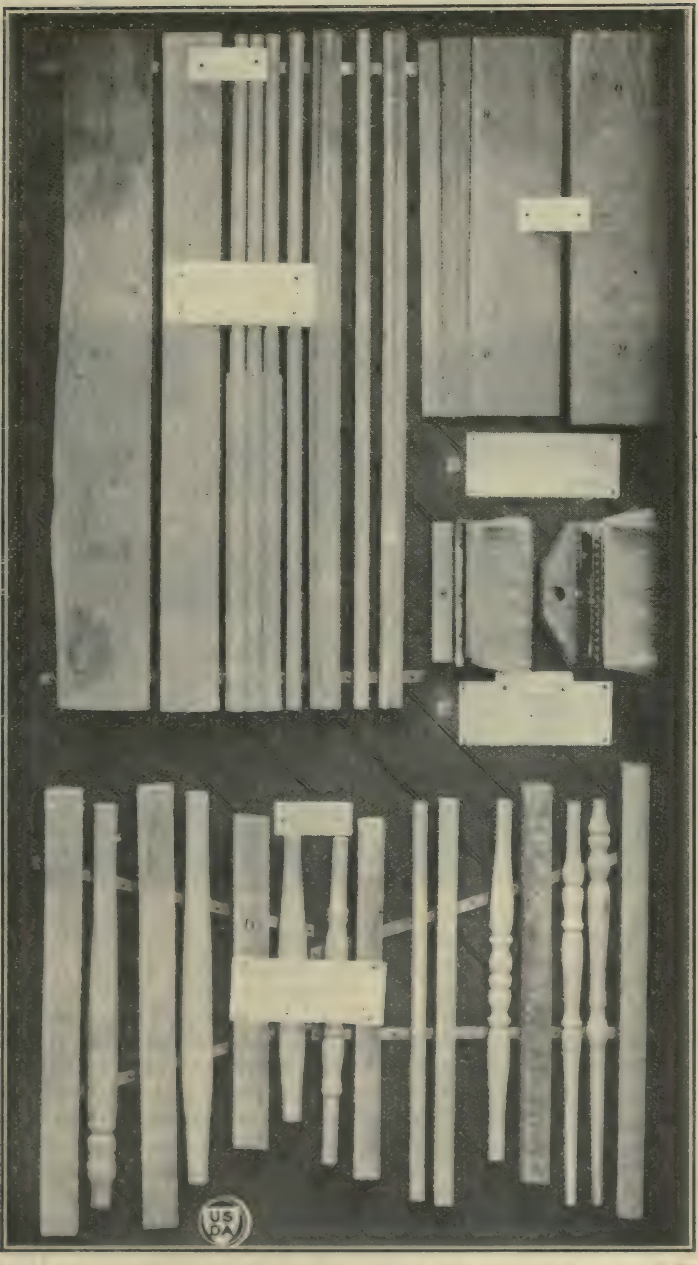

FIG. 4.—Higher costs and technical research are teaching us to utilize our timber with greater economy, to waste less in the logging camp and sawmill.

While the pinch of high prices has greatly reduced the per capita consumption of lumber in the United States, this has not been without some gains. A part of the lumber formerly used in construction has been advantageously replaced by metals, cement, or clay products. A part of the wood formerly used for fuel has been replaced by coal, oil, or electricity. Further substitutions for wood, doubtless on an increasing scale, must be expected. In the main they are desirable, for they represent more durable types of construction and higher standards of living. We have bid good-by to the plank sidewalk and the wooden railroad bridge, and we hope never to see them again.

Higher costs and technical research are also teaching us to utilize our timber with greater economy, to waste less in the logging camp and sawmill, to convert the refuse of the lumberman into raw material for the paper maker, to save loss at the refabrication plant by sawing logs into the sizes which can be reworked for furniture or vehicle parts with the least waste, and to prolong the life of railroad ties, mine timbers, and telegraph poles by preservative treatment. (Figs. 4 and 5.) By such savings it is possible to reduce the yearly drain upon our forests by 6 or 7 billon board feet, while still obtaining the same economic service from them. This is equivalent to the present annual growth of wood on 170 million acres of forest land.

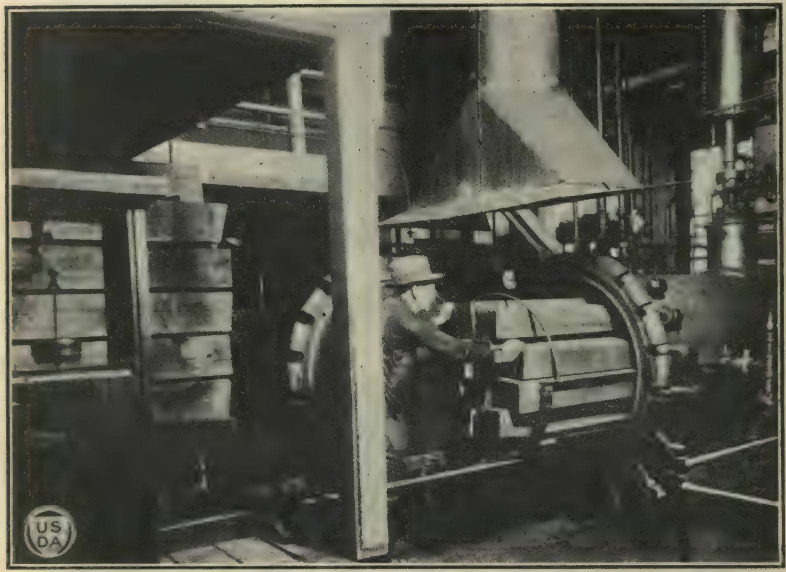

FIG. 5.—Through preservative processes the average life of the railroad tie is prolonged many times. A great deal of pioneer experimentation in this line is conducted at the Forest Products Laboratory, Madison, Wis.

But after all has been said, too little wood is being used in the United States to-day. We are paying the penalty for idle forest lands in unbuilt homes, poorly improved farms, and an uncertain future for many industries. It is impossible to say exactly how much timber the United States does need. The nations of the Old

World which are advancing industrially require more wood from decade to decade, not less; and we are preeminently an industrial nation. We have a tremendous inherent demand for forest-grown material. We have developed national habits and industries fostered by unprecedented supply of cheap timber. We are already compelled to curtail its use, and we are suffering from the curtailment. Undoubtedly we must curtail still more before we can reach a stable basis of timber supply. Substitute other materials as far as they will go; employ every device to eke out the stumpage we now have—yet the enforced reductions in the use of wood will unquestionably entail serious losses in many phases of American life. Our present consumption of timber is the very least that should be taken as the basis for a national policy of reforestation; and even this amount will necessitate a steady reduction in per capita consumption as the population grows.

HOW CAN OUR TIMBER NEEDS BE SUPPLIED?

The United States has obtained its timber hitherto mainly from a temporary and exhaustible supply. Just as we have drained one oil field after another, we have drained one big reservoir of virgin timber after another. Seventy-five per cent of the lumber cut and fully 90 per cent of all high-grade timber products still come from virgin forests.

The total yearly drain upon our forests is nearly 25 billion cubic feet, 22½ billion cut for use and 2½ billion destroyed by forest fires, insects, and tree diseases. This yearly drain is but partially replaced by new forest growth. We are using up the saw timber of softwood species over eight times as fast as it is being regrown, the softwood timber of all kinds nearly five times as fast as it is being regrown, and the remaining hardwood timber over three times as fast. The current cut of all timber varieties and products, including fuel wood and other minor products of the forest, is about four times the rate of replacement. In other words, 25 per cent of our present use of wood may be said to represent our forest interest. The other 75 per cent is a direct and unreplaced drain upon our forest capital.

Foreign supplies of timber will prove a broken reed on which to lean after our own last reservoirs of virgin forest are exhausted. The present exports and imports of lumber and other forest products nearly balance. Our imports may be expected to increase somewhat, particularly of print paper from Canada and of lumber in limited quantities from certain of the Canadian provinces and from Mexico. The hardwood forests of South America and the softwood forests of Siberia hold out problematical prospects of relief. The markets of the world are short of raw materials for paper and construction lumber. A survey of the principal wood-using countries shows that the accessible supply of timber, particularly of coniferous timber, is not adequate to meet the requirements of the twentieth century. The cost of transporting Asiatic or South American lumber to the United States, on top of prices at the source fixed by keen international competition, will be well-nigh prohibitive for ordinary construction or industrial purposes. In supplying the enormous consumption of wood in the United States, such sources will prove at best small driblets into an enormous bucket.

We must replace our present temporary and exhaustible source of timber not with one equally temporary and more uncertain on foreign soil but with a stable and self-sustaining supply at home. The means for doing so are at hand by utilizing the productive power of our forest land.

On 470 million acres of forest land, the United States is now producing about 6 billion cubic feet of wood annually. This new growth is largely concentrated on the cut-over lands in better condition. Most of it represents haphazard natural growth with little or no human care beyond partial prevention of fire. If all our forest lands were protected from fire and the simplest measures of reforestation practiced, such as leaving a few seed trees in logging, the current growth of wood could probably be increased to 10 billion cubic feet annually now, and ultimately, when most of the remaining virgin forests have been cut, to as much as 14 billion cubic feet. This is obviously the first goal to attain; but it is only a half-way step. It will still leave us far short of a sustaining supply of timber.

All the data obtainable on what our forest lands will produce, once their growing power is brought fully into play by intensive forest culture, go to show that an average yearly production of 58 to 60 cubic feet per acre is attainable. This is comparable with the results secured in the well-managed forests of Europe. Once that rate of growth is generally attained, and it is already exceeded in parts of the United States, we shall have an annual wood crop of 27 billion cubic feet, or a little more than the present total drain upon our forests. It will take a long time to bring this about; but its accomplishment, and only its accomplishment, will give the United States a sustaining supply of timber adequate to her requirements. (Fig. 6.)

HOW FAR HAVE WE GOT IN TIMBER GROWING?

The "second growth" timber thus far produced in the United States, for the most part, has been a wild-land crop, like huckleberries. National habits in the use of land change slowly, and timber mining still goes on apace. Nevertheless we have made a fair start in forestry.

Growing crops of wood like crops of wheat requires an owner who has a permanent interest in the land and its earning power. Twenty-one per cent of the 470 million acres of forest land in the United States is owned by the public—Nation, State, or municipality. Most of these public holdings, particularly the State and National forests, are dedicated to timber culture for all time. During the last decade public agencies have acquired land for this purpose at the rate of nearly 1 million acres a year. Thirty-two per cent of the total forest land area, or around 150 million acres, is in farm woodlots, a form of private ownership that is relatively stable and, to a considerable degree, already ripe for forestry. The remaining 221 million acres, or 47 per cent of the whole, is owned by lumbermen, paper makers, mining companies, railroads, and others whose interest in the land is wholly commercial and but few of whom have yet looked farther ahead than cutting the merchantable timber now standing.

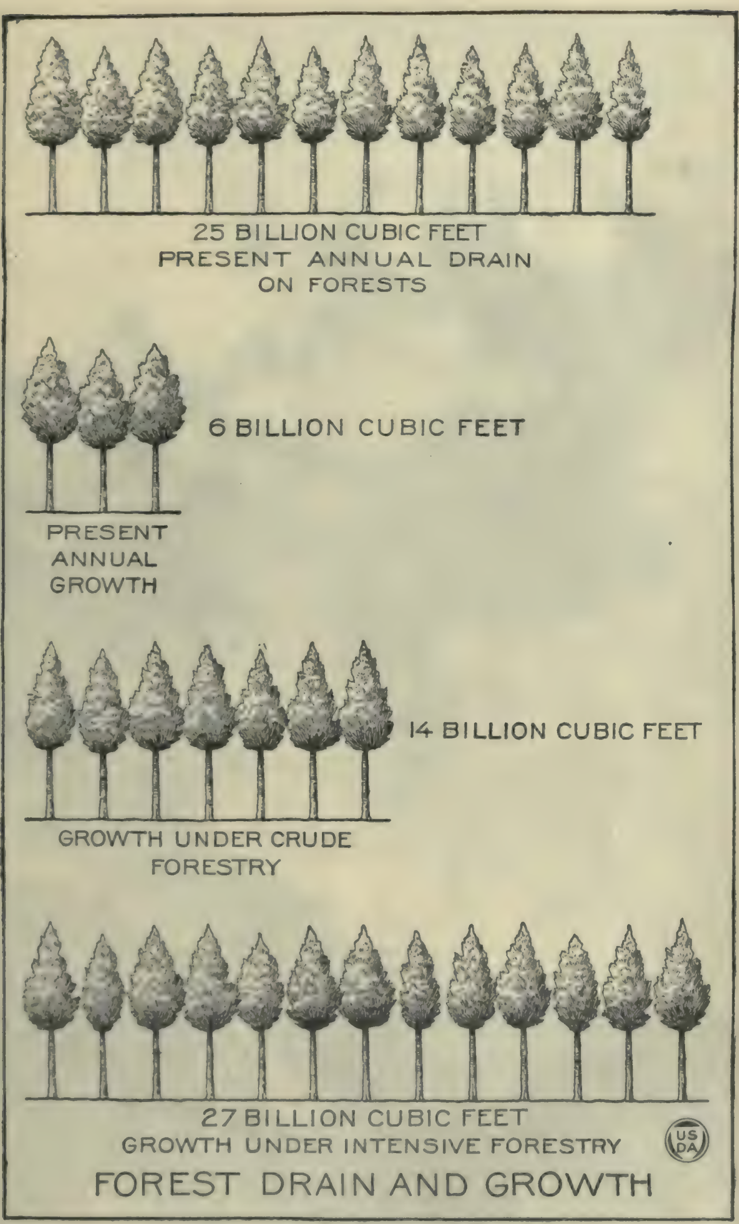

FIG. 6.—The annual drain on our forests is four times as great as the amount of wood grown by them each year, nearly twice as great as we could grow under crude forestry, and almost as great as what we can expect to grow under the most intensive methods on our present forest area of about 470 million acres.

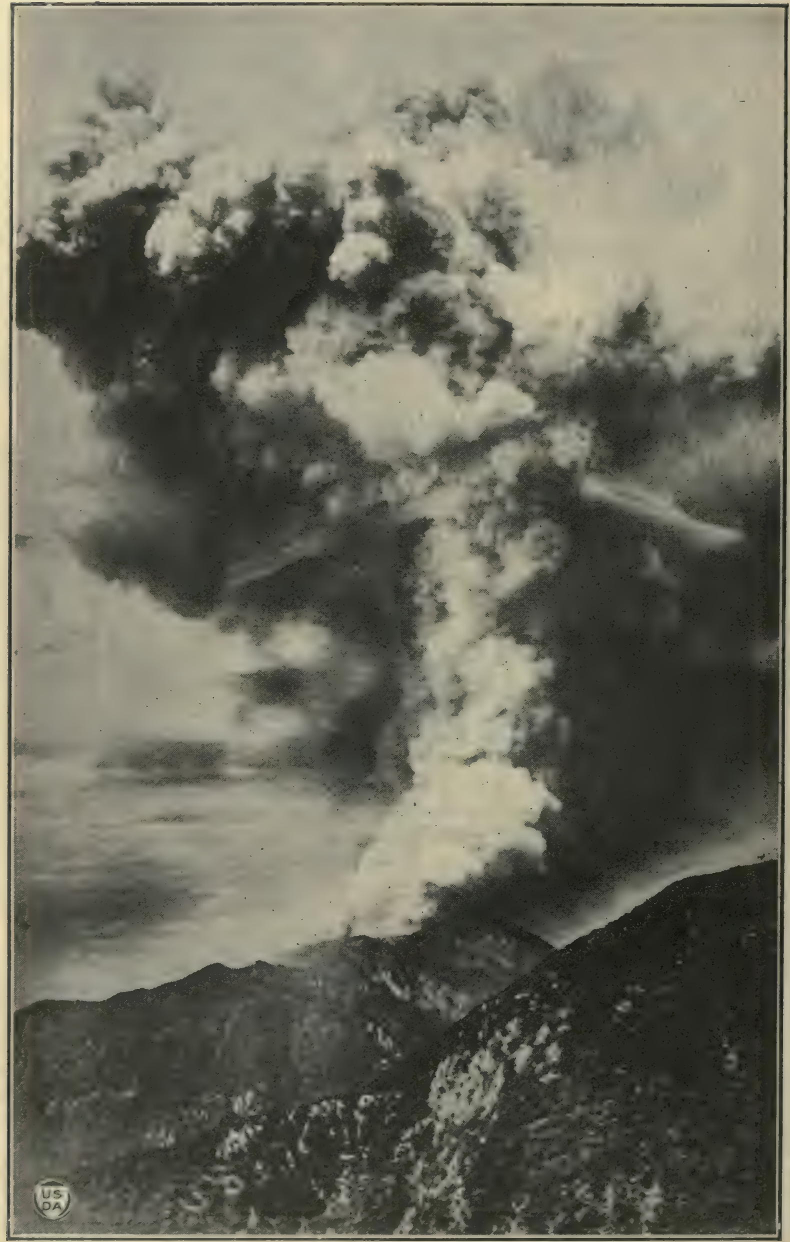

FIG. 7.—We still have around 33,500 forest fires annually, which sweep over more than 7,000,000 acres. The country now expends $3,300,000 annually for safeguarding the vast present and potential forest resources in private ownership; but the **job is still two-thirds undone.**

Aside from the creation of public forests, the greatest gain thus far made in forest conservation has been through reducing the loss from fire. Forest fires have not only levied an enormous toll upon our commercial timber but have destroyed many millions of acres of young tree growth and kept a large part of our forest land in barrenness. We still have around 33,500 forest fires annually, which sweep over more than 7,000,000 acres. (Fig. 7.) Fifty-four per cent of the forest lands in the United States are now more or less adequately protected from fire. This includes 95 million acres of Federal and State holdings, and about 160 million acres of private land.

Of the 39 States which contain important forest areas, 27 have some form of organized protection. Including the Federal aid extended for protecting the watersheds of navigable streams, the country now expends about $3,300,000 annually for safeguarding the vast present and potential forest resources in private ownership; but the job is still two-thirds undone. At least 150 million acres of forest land, largely in the Southern States, is wholly without protection.

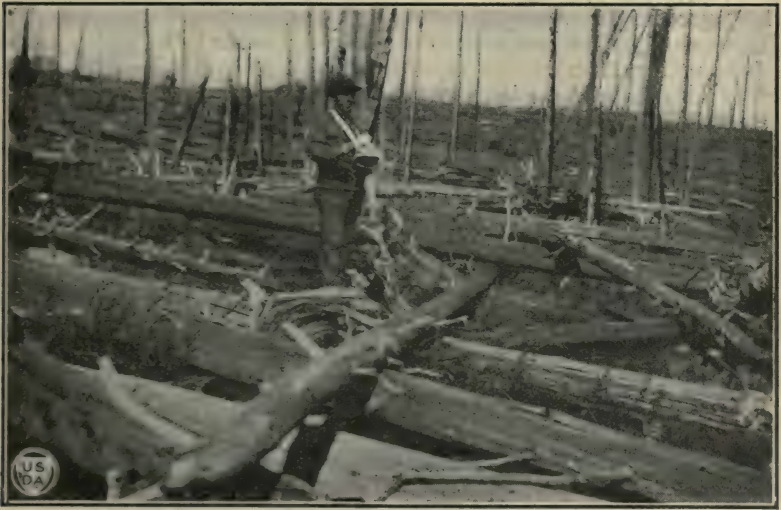

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FIG. 8.—About 1½ million acres have been planted to date while 81 million acres of fire-swept and barren land that once grew timber remain to be planted.

The protection of forests from fire, and no less from destructive insects and other pests, is clearly recognized as the first thing that must be done. It stands toward national reforestation as the clearing of land to agriculture or laying a foundation to the erection of a skyscraper. It is receiving tremendous impetus from both public and private sources, and fresh ground is gained every year.

Tree planting thus far represents but a few drops into an immense bucket of denuded land on which every vestige and possibility of valuable tree growth have been destroyed. About 1½ million acres have been planted to date as against 81 million acres of fire-swept and barren land that once grew timber. (Fig. 8.) Thirty-six thousand acres of planted land are being added to our productive forest resources yearly. On the other hand, it should be remembered that 10,000,000 acres of forest land is cut over yearly. Though our area of denuded land were to be no further augmented, to reclaim 81 million acres at the present rate would require 2,250 years. Several States, however, have made notable progress in planting their own holdings and in encouraging the planting of private land with young trees furnished at cost from State nurseries. A rapid extension of tree planting is one of the most encouraging signs of the times.

For many years in the United States, timber growing as a deliberate and organized use of land was limited very largely to public undertakings. Foreseeing future public necessities, the National Government and a few of the States set about to meet them by the conservative harvesting of timber on lands which they controlled and by growing new crops of wood with such scientific skill as they could muster. The menace of a timber famine was given added force by recognition of the imperative need of protecting our waterways and irrigation and power developments at their mountain sources. Public forestry was launched, like most measures of general welfare, without weighing prospective returns against the cost; but at the same time with entire faith in the economic soundness of the enterprise.

Thus the 80 million acres of timbered and young-growth lands in the national forests were put under a scheme of management designed specifically to secure an unbroken yield of forest products and the complete reforestation of every cutting. When fully utilized, they will furnish perpetually from 6 to 8 billion board feet annually of saw timber, railway ties, pulpwood, and like products, or one-sixth or more of our present consumption of these materials. In like fashion some 7 million acres of State forests have been placed under forms of administration designed either to promote continuous growth or to preserve their existing timber.

THE OUTLOOK FOR PRIVATE FORESTRY.

Within the last 10 years or so, a new force has entered the lists as an ally of public foresight, wearing the green tree on its escutcheon. It is none other than our old friend, "supply and demand," the commercial incentive to grow trees because tree growing pays. The depletion of our stocks of virgin timber has had a striking effect upon the value of forest growth, particularly since 1900. The main sources of lumber have become more and more distant from the large eastern markets. Rising costs of transportation have been reflected in higher and higher levels of retail lumber prices. And these in turn have as steadily enhanced the value of the timber which was still left or which has been regrown in the older lumbering regions.

In practically no instance have the recognized commercial timbers in any eastern forest region increased in value less than 200 per cent during the last 20 years, and in many cases the enhancement has been much greater. Virgin yellow pine in the Gulf States has advanced from an average value of not more than $1 per thousand board feet in 1900 to an average of at least $9.50 in 1920. Second-growth yellow pine in Maryland, Virginia, and North Carolina, cut when only 40 or 50 years old, brought $9 or $10 per thousand feet in 1920 as compared with $3 in 1900. Spruce stumpage in Maine rose during the same period from $2.50 to $8.25 per thousand feet and sales as high as $12 have been reported. The rise in prices paid for hardwoods in Indiana, Ohio, and southern Michigan has been even more remarkable. Prior to the war from $16 to $18 per thousand feet was paid for tracts of white and red oak, basswood, elm, and ash, and the war and post-war values have been much greater. The second-growth white pine of central New England, often cut when but 30 or 40 years of age, was worth about $4 per thousand feet in 1900 but now averages about $16 and has brought as high as $25 per thousand.

In all of these regions, the much closer utilization of the standing timber brought about by higher values and more diversified markets has added greatly to the net returns from a forest crop. Cases are not rare where a 40-year crop of second-growth white pine in the Northeast represents to its owner, as it stands, a value of $300 or more per acre. The prevailing prices of both hardwoods and conifers in several forest regions of the United States, particularly of second growth, have already reached or passed the pre-war values obtained for the man-grown timber of France, Germany, and Sweden.

In other words, the very process of timber depletion is, though slowly, working out its eventual cure. Region by region, it leads inevitably to higher price levels in favor of local forest growth. Region by region, it leads inevitably to a point where plan-wise timber growing becomes commercially feasible and is well-nigh compelled by purely economic forces. On the 79 per cent of our forest land in private ownership, the aggregate showing in real timber culture is still small. A striking advance has been made in parts of the Northeast, where high timber values and opportunities for exceptionally clean use of forest-grown materials have given impetus to the growing of timber crops. Probably one-sixth of the forest area of Massachusetts, and doubtless of other New England States, is under some systematic form of timber culture. The Northeast furnishes many examples of forest properties, large and small, which have long maintained an almost unbroken timber growth.

Every year the economic pressure for growing wood becomes still more potent. Every year the acreage used for growing forest crops under more or less intensive methods is widening. It is slowly speading over New England and the Middle Atlantic States. It is creeping down the Atlantic seaboard. It is making gains on the Gulf coast and in the Lake States. Even on the Pacific coast, where virgin timber is still plentiful and cheap, systematic timber growing is beginning at exceptionally favorable points like the redwood belt of California.

But the people of the United States still have an immense task in front of them before a stable and self-sustaining supply of timber shall have been substituted for the temporary and exhaustible one from which our enormous appetite for wood has hitherto been satisfied. It would be folly to indulge in a narcotic dream that the whole problem will solve itself without active and aggresive public participation. The most that can be said is that the ebb tide has turned. We have made a start.

HOW CAN WE PUT TIMBER CROPS ON OUR IDLE LAND?

For half a century the area of cut-over forest lands in the United States not devoted to agriculture has increased steadily. It now has reached nearly 200 million acres, which, for the most part, seems destined to produce timber or nothing. For its own social and economic welfare no State can afford to support vast areas of idle land.

On the other hand, we can no more do without timber than without wheat or steel. Even with a declining per capita consumption of wood and the free use of subsitute materials, the normal requirements of the country with its demands for better housing in town and country, its expanding industries, and its rapidly increasing use of pulp and paper, will not be satisfied with much less than 22,500,000,000 cubic feet which we now cut annually from our forests. Nor can we continue for very many years to draw 75 per cent of what we use from our timber bank account. The drafts will presently be returned endorsed "No more funds." If we would have wood on anything approaching an adequate scale, we must grow it.

The answer is simple enough. One stone will kill both birds. Growing trees will give our idle lands something to do and at the same time keep us out of timber bankruptcy. The best of it is that the answer is complete. The available land is ample. Putting the consumer's money into growing trees in his own State instead of transporting lumber from mills 2,000 to 3,000 miles away will create a permanent supply of timber without materially increasing the cost of forest products to the user, and without necessitating any permanent reduction in our consumption of wood.

Yet it will not do to leave the whole matter to private initiative and the slow action of economic forces. Timber depletion will be followed by timber growing, but not quickly enough to provide contionously for our national needs. A very material temporary reduction in our consumption of wood is inevitable because extensive timber growing did not begin years ago. Long-standing national habits in the use of land and its resources change slowly.

Public interest, indeed public necessity, must in time impose certain obligations of stewardship upon the owner of forest land. The public has a right, if the right is reasonably and equitably exercised, to see to it that forest lands are kept at work, but at the same time must be ready to pay the price of reforestation as part of the cost of forest products. This, however, is not yet clearly seen by the American people. It will be the course of wisdom to concentrate public efforts immediately upon the things all are agreed can and should be done now. These are (1) to reduce the hazards and uncertainties in growing timber crops and thus give full play to the already powerful commercial incentives for reforestation; and (2) to extend public forest ownership, give ample public aid in tree planting, and provide nation-wide education in timber growing and economy in timber use.

THE FIRE PROBLEM.

The greatest hazard to reforestation will disappear when fires are kept out of the woods. That alone would probably double the rate at which timber is grown in the United States. The gains which we have made thus far in preventing forest fires have been largely through the cooperation of the Federal Government with the States, and of these public agencies in turn with forest owners or groups of forest owners. The policy of national cooperation with the States in protecting the forested watersheds of navigable streams was launched by the Weeks law in 1911. Although the net participation of the Government in the cost of forest protection has been meager, its cooperation has been instrumental in establishing forest patrols in 15 additional States and over a much greater area of timbered and cut-over land. One of the most obvious and necessary things to be done now is to extend this national policy of cooperation much more widely, until it reaches every one of the States which contain important areas of forest land, in a country-wide drive to outlaw the forest fire.

Aside from extending forest patrols and creating the machinery for quick and effective fire fighting, no small part of this drive must be directed to stamping out the hazard at its source. This requires State laws which will prevent the setting of fires by railroads and the deliberate or negligent burning of the woods, from whatever cause or motive. And it requires a sustained campaign of public education which will teach the every-day American, young and old, that a fire in the woods is on all fours with a fire in a grain field or a neighbor's barn.

THE TAX PROBLEM.

Another hazard often encountered in commercial timber growing is the risk of accumulated taxes beyond what a crop which yields a harvest but one in 40 or 50 years can carry. Annual taxation of young forests is not unlike taxing a field of potatoes 20 to 30 times between seed time and harvest. Unless very moderate it may eat up much of the value of second-growth timber by the time it is ready for the ax. Many owners regard the present tax levies on forest land or their probable but uncertain rise in the future as closing the door to the business of timber growing.

It is not to be expected that forest lands can be exempted from paying their fair share of public revenue; but an adjustment of the method of taxation to the long-time nature of forest crops is widely recognized as equitable and necessary. A number of States have enacted special laws for taxing forest lands, mostly based upon deferring the major part of the tax until timber is harvested. Their results are still inconclusive. The problem is not one which can be solved overnight. It requires study by State tax commissions and public forest agencies with a view to working out methods of taxing forest lands which will give reasonable encouragement and security to commercial reforestation. This barrier, or handicap, to growing timber as one of the great staple crops of the United States must be removed.

MORE PUBLIC FORESTS NEEDED.

While the progress of the United States as a timber-growing nation can be aided materially, in the long run, by giving nature free play through stopping forest fires and by giving commercial forces free play through a rational adjustment of forest taxation, there are other things that the American people should do. Our greatest progress in forestry up to the present time has been made through public forest ownership. It is significant that the forward nations of the world in forest conservation have almost uniformly found it necessary to create a core of publicly owned forests to give stability to their timber supply, to set the pace in technical forest management, and to demonstrate to their forest owners at large the ways and means of successful timber growing. Particularly has the production of timber of large size and high quality proven, in the main, to be a public task, which the private forest owner ordinarily can not assume. The United States will be no exception to this general rule. We need more publicly owned forests.

Twenty-one per cent of our forest area is owned to-day by the Nation itself and by various States. It is neither practicable nor necessary for public agencies to acquire a large part of the 370-odd million acres of forest land in private hands. But there is a clear need for extending public ownership, particularly of the kinds of forest land which will be the slowest to respond to commercial incentives for timber culture and whose restoration to productive forests will be the most difficult. The vast areas of denuded land in the Lake States, in the southern pineries, and in the Alleghenies, the very regions where ample timber supplies in the future are critically needed by our largest centers of wood consumption, offer particularly urgent and fruitful opportunities for public acquisition.

Since the Weeks law was passed in 1911, 2,142,000 acres have been bought or approved for purchase under its terms, on mountainous watersheds in the Eastern States. Much additional land remains to be acquired before the original program contemplated by this measure for the protection of navigable streams will be completed. There are other areas where the establishment of national forests would be desirable, "key areas" where this form of public ownership would not only protect important watersheds and add directly to the volume of timber growth, but where they would break the ice and help in starting whole new regions in the paths of forest protection and timber culture. And the Weeks law policy might well be expanded to include Federal acquisitions in the big, black belts of denuded land where the protection of streams is relatively less important but the growing of timber is a matter of vital national concern.

There is every reason, too, why States and municipalities should extend their ownership of forest land. Putting idle land at productive employment and building up local supplies of timber will well repay such investments of public funds in future prosperity. And every additional acre of green forest that is created adds to the opportunities for wholesome recreation available to their people. There is not a State in the Union which will not build more securely for its future by acquiring State forests or planting State forests and then intelligently developing and conserving them for the varied forms of public service which they can render. It is particularly incumbent upon the great industrial States which contain enormous areas of denuded, idle, and depopulated land at the very doors of their cities and factories to take an aggressive part in restoring this land to solvency and to social and economic service.

While public agencies are buying forest land, they should not overlook the opportunities and obligations at hand in the sane use of the land which they already own. There are still large areas of timbered and cut-over land in public ownership in whose management or disposition timber growing has no part. American public opinion, once fully awakened to the double menace of idle land and depleted forests, will demand that the timbered portions of the still unreserved and unprotected national domain, the forest lands in State ownership still in process of distribution or destructive lumbering, and the logged-off areas receded for tax claims be all placed under forms of administration in harmony with the nation-wide need for forest renewal.

THE PUBLIC SHOULD HELP TREE PLANTING.

Another direct and practical way to get more timber grown is through public aid in tree planting. On enormous areas of burnt-out woodland and abandoned farms, new forests of real value can only be started by hand. It takes from 700 to 1.500 seedlings to plant an acre. If appreciable progress is to be made in restocking the denuded lands whose forests nature can not restore, hundreds of millions of seedlings must be grown annually and made available to the landowners at low prices. The States which have undertaken to supply this need from State forest nurseries are unable to meet the present demand for planting material, and must enlarge their facilities. Additional States should equip themselves to aid their landowners in this telling and common sense fashion. We need a chain of public-forest nurseries, extending into every region and furnishing, at cost, the kinds of young trees needed to plant such of its lands as will not reforest themselves. Here is a fine opening for cooperation on the part of the National Government.

EDUCATION AND RESEARCH NECESSARY.

In a very important sense, the forest problem of the United States is primarily a problem of education. We must, as a people, grow out of old habits of mind and practice regarding timber and land that will grow timber. We must become a people skilled in the craft of producing wood as a staple crop, and in the art of using wood with intelligence and thrift. The facts necessary to guide and stimulate this evolution must be dug out and made common property. In the nature of the case, this must be done to a large degree by public agencies and its accomplishment should be an important aim of public policy.

By reducing waste in the use of timber it is possible to save 1 cubic foot of wood out of every 3 that we now cut annually from our forests. This can be accomplished by research in the manufacture and use of forest products and by the wide dissemination of its results among the sawmills, wood-using factories, paper plants, lumber yards, and everyday consumers of their wares.

By scientific study of timber culture we can make our available forest land produce ultimately all the timber that we need, and at a cost that will still keep it within reach for generous and universal use. This can be accomplished by forest experiment stations in each of the great timber producing belts of the country, stations that will give the timber grower the same sort of technical and practical help that our agricultural experiment stations give the farmer. By showing how to grow timber and the opportunities to grow timber profitably, we can hasten the day when all of our forest land will be productively employed and wood will become a staple crop. Take, for example, the 4 million farmers who own woodlots. If forestry is made part and parcel of our agricultural lore, or land sense, an enormous increase in the volume and value of the wood grown as a farm enterprise can undoubtedly be brought about in no great space of time. Here is a possible farm crop for which there will never be a glutted market. Extension work in farm forestry might well be made a special field for Federal and State cooperation; and it will reach nearly a third of all the forest land in the country.

FIG. 9.—If forestry is made part and parcel of agricultural lore, or land sense, an enormous increase in the volume and value of the wood grown as a farm enterprise can undoubtedly be brought about.

THE NEED FOR ACTION URGENT.

Idle land and costly lumber—these are not vague or illusory glimpses into the future. They are here. The United States is suffering from them to-day. It will suffer more acutely as time goes on. They present very tangible and concrete problems which the present generation of Americans must solve. Their solution is bound to be a long, hard pull. We may not all agree on every step that should be taken before it is complete. But that is small reason for delay or hesitation in getting at the obvious things that must be done now.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

January 30, 1924.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1418

LETTUCE GROWING IN GREENHOUSES

1862 1889

CRISP, TENDER LETTUCE, such as may readily be produced in greenhouses and placed in the hands of the consumer within a few hours from the time it is harvested, is increasing in popularity.

The crop may be grown in simple, inexpensive greenhouses, but correspondingly better results can be had when a large modern greenhouse is used.

Success in the growing of greenhouse lettuce depends on the use of a soil well supplied with organic matter and available plant food, the control of diseases and insect enemies of the crop, the use of varieties and strains adapted to the needs of the grower and the market to be supplied, and the closest attention to every detail of the management of the crop.

Satisfactory financial returns can be secured only when a well-grown high-quality crop is packed in an attractive manner in containers of suitable size and placed in the hands of consumers in the shortest practicable time.

Washington, D. C. Issued November, 1924

LETTUCE GROWING IN GREENHOUSES

By James H. Beattie, *Horticulturist, Office of Horticultural Investigations, Bureau of Plant Industry*

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SURVEY OF THE INDUSTRY

THE wonderfully refreshing qualities of lettuce have made it by far the most widely used of the salad crops. Crisp, tender lettuce, such as is produced in modern greenhouses, can be delivered to the markets within a few hours after the product is harvested. Greenhouse lettuce is not only the most important of the vegetable forcing crops, representing a large portion of the annual value of these products, but is also the oldest vegetable forcing crop grown in the United States, as large quantities of lettuce were produced in hotbeds and coldframes before the greenhouse began to attract attention for the culture of this crop. The production of lettuce in hotbeds is limited by the seasons, for it is seldom practicable to open a hotbed during cold weather without danger of injuring the crops. Some growers utilized modified hotbeds heated with a flue or with hot-water heat and so arranged that it was possible to enter them by using depressed walks.

Simple greenhouses built with the walks excavated below the surface and the roof made of two rows of hotbed sash with a ridgepole in the middle soon came into use for the forcing of lettuce, and these quickly demonstrated the practicability of producing greenhouse lettuce as an all-winter crop. Greenhouses of the type employed for the production of floricultural crops early came into use for the forcing of lettuce and shortly afterwards for the forcing of cucumbers, tomatoes, and other crops. Growers found that the economical production of vegetable forcing crops demanded a special type of structure, and the development of the modern vegetable-forcing house has been the result.

Boston, Mass., was the center of the first important greenhouse-lettuce industry; as early as 1880 at least one grower in that section was producing lettuce in glass houses. This was soon followed by a similar development at Grand Rapids, Mich., and the success of these early growers led to the establishment of the industry in northern Ohio, Rochester, N. Y., Philadelphia, Pa., and many other points, until at the present time large glass-farming enterprises are to be found devoted to the forcing of vegetable crops in practically all sections of the United States.

The heading sorts are far more difficult to produce satisfactorily than are the loose-leaf varieties, and this has led many growers to devote their attention to the production of Grand Rapids or other loose-leaf kinds. While the difficulties often experienced in securing good yields of high-quality greenhouse-grown head lettuce deter many growers from attempting the production of these sorts, the uniform success of producers in the Boston, Mass., district and other sections where the forcing of head lettuce is an important industry shows that it can be done, provided the crop be grown at the right season of the year and handled in the proper manner. Extreme care in preparing the soil, in controlling temperature, in ventilating, and in watering are necessary. Careless application of water, especially after the heads have begun to form, is liable to induce drop and other troubles. Many successful growers do not wet the plants at all during the heading period, depending on subirrigation or on the supply of moisture already in the soil for the maturing of the crop. Inexperienced persons should master the production of loose-leaf lettuce before attempting the growth of the more difficult heading kinds, for while the general cultural requirements of head lettuce are not materially different from those for loose-leaf varieties, it is a task for the most skillful greenhouse operators.

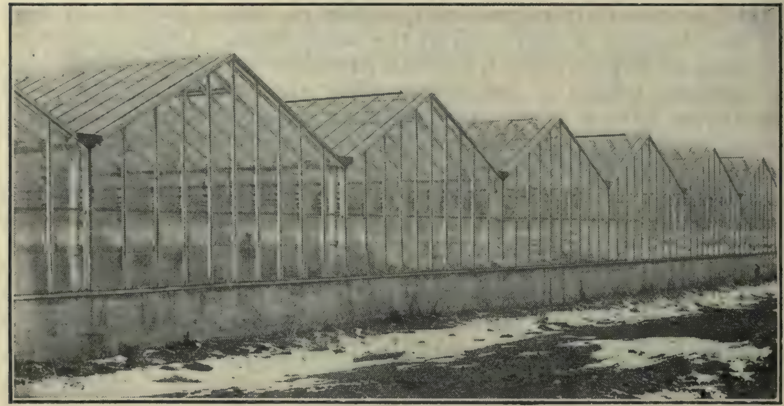

FIG. 1.—Ridge-and-furrow greenhouses, extensively employed for the forcing of lettuce and other crops

Profitable returns have not always been secured from the production of greenhouse lettuce, especially loose-leaf lettuce. The crop thrives at a low temperature, and great quantities are produced in frames and even outdoors in the milder sections of the country, much of this coming into competition with the greenhouse product. Unless the transportation charges be such that a differential is established in favor of the greenhouse product, its production may become unprofitable. Having control of most of the factors influencing the development of the crop, the producer of greenhouse lettuce is able to handicap the long-distance shipment crop by growing a high-grade product, and, moreover, he can place it on the market in a perfectly fresh condition. Constant improvements are being made in structures for the production of the vegetables included in glass-farming enterprises, making it possible to secure crops with a minimum of fuel and labor. These and other factors help the greenhouse man to compete more successfully with outdoor crops.

GREENHOUSES SUITED TO LETTUCE GROWING

Lettuce is not particular as to the type of forcing structure in which it is grown, and it is produced in many kinds of greenhouses, but cucumbers and tomatoes, being very particular as to their growing conditions, require greenhouses of a special type. Owing to the fact that the vegetable-forcing industry usually includes the production of several crops, it is necessary to use structures suited to the requirements of all the crops grown. Lettuce, cucumbers, and tomatoes are the crops to which the most attention is devoted, and they comprise a very large portion of the annual value of the vegetable forcing crops grown in the United States. Naturally the houses must be made to suit these difficult crops, which must have a rather high and very uniform temperature and freedom from draft, this necessitating excellent heating equipment. While such houses are not absolutely essential to the successful production of the more hardy types of lettuce, it is unquestionably true that the crop thrives better in good greenhouses than in very simple structures. Those proposing to grow lettuce as their main crop will find it advantageous to build a good type of greenhouse.

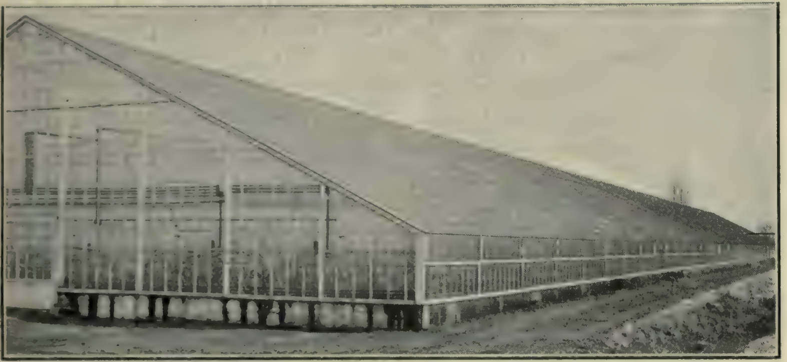

FIG. 2.—Steel-frame greenhouses, from 40 to 100 feet wide and any desired length, largely used for the production of lettuce and other forcing crops

The growing of greenhouse lettuce has developed to a point where growers often look upon it in terms of acres of land inclosed. The modern vegetable-forcing house is a structure designed to cover the desired area of ground with a roof and side walls, making it possible to maintain this at temperatures and other conditions suitable for the successful production of the various crops. Houses of the ridge-and-furrow type (fig. 1) make it possible to inclose an almost unlimited area of ground in what is practically one large house. Such houses are employed by some of the most successful producers of greenhouse lettuce. Large steel-frame houses (fig. 2) are extensively employed for the production of lettuce and other forcing crops, and such structures secure almost ideal conditions for their production. In the Boston area, where the production of lettuce in greenhouses has reached the greatest perfection, the so-called uneven-span house is the type almost universally employed. These structures as a rule are from 32 to 36 feet wide and from 200 to 600 feet long, with the ridge to one side; hence the name uneven span. They are so located that the long side of the roof has a southerly exposure. Other types are largely used for the growing of greenhouse lettuce, but in practically all houses the crop is grown on ground beds, as raised benches add to the expense and are not desirable for lettuce growing.

RELATION TO OTHER FORCING CROPS

Of the three important vegetable forcing crops, lettuce alone does well as a midwinter crop. Neither cucumbers nor tomatoes will make a satisfactory development during the short days of midwinter, and for this reason nearly all vegetable growers plant their houses to lettuce during this period. Some growers produce a crop of fall tomatoes, which occupy the space until about the first of January; then plant the space to lettuce, producing one crop; then plant cucumbers; or producing from two to three crops of lettuce occupy the houses until summer. In other cases lettuce is planted early in the autumn and successive crops produced until time to plant cucumbers in spring. The following planting plans are followed quite closely by many large growers:

Plan and crop	Seed sown	Plants set	Crop harvested
Plan 1: [1]			
Tomatoes	July 1-15	Aug. 15-30	Dec. 15-31
Lettuce	Nov. 15-30	Dec. 15-31	Mar. 15-31
Cucumbers	Feb. 1-15	Apr. 1-15	July 1-31
Plan 2: [2]			
Tomatoes	July 1-15	Aug. 15-31	Dec. 15-31
Lettuce	Nov. 15-30	Dec. 15-31	Mar. 15-31
Do	Feb. 1-28	Mar. 15-31	June 1-15
Plan 3:			
Lettuce	Aug. 1-15	Sept. 1-15	Nov. 15-30
Do	Oct. 15-30	Nov. 15-30	Feb. 1-28
Tomatoes	Jan. 1-15	Mar. 1-15	Before Aug. 1

[1] The time between the removal of the cucumbers and the planting of tomatoes is used for soil sterilization.

[2] In part of the space it is possible to grow a third crop of lettuce. Growers who follow this cropping plan usually count on two and one-half crops of lettuce.

These plans may be modified to suit conditions. In many large ranges it requires two weeks for the entire planting; consequently no exact dates can be observed. It is, in fact, desirable that the planting be extended over a period, as with lettuce it makes it possible to plant and harvest continuously. As soon as the crop is removed the soil is prepared for another crop.

INTERCROPPING

Owing to the fact that a fair crop of loose-leaf lettuce can be grown in about six weeks from the time the plants are set in the houses, it is sometimes used as an intercrop between such greenhouse crops as cucumbers. Figure 3 shows a range where this plan is being followed. While the lettuce grown in this manner is of a rather poor quality, because the temperature is usually carried at the point best suited to the other crop and it does not have sufficient time to make a heavy yield, this practice frequently makes it possible to secure an appreciable additional return. Lettuce of the Grand Rapids type is sometimes grown as an intercrop with tomatoes, but here, too, the temperature best suited to tomatoes is too high for lettuce, and it must be removed before it has time to make a good growth. When planted as the main crop, it soon fully occupies the ground, leaving no space for companion crops. Head lettuce is more particular in its cultural requirements and is not well adapted to being grown as an intercrop with tomatoes, cucumbers, and other forcing crops demanding higher temperatures.

SOIL AND ITS PREPARATION

A naturally deep, well-drained, friable soil is considered best for the growing of greenhouse lettuce. The plant has a large root system, and it is particularly desirable that the soil be deep. Soils characterized as loams, containing a considerable portion of sand, are well adapted to the crop. While many growers of the loose-leaf type of lettuce use soils of a rather heavy character, producers of head lettuce consider some sand an essential part of the soil used. As several different vegetable crops are produced in most ranges, the soil must be suitable for all. The important forcing crops do best on soils having a fairly light texture, and it is not difficult to select one well adapted to all the crops to be grown. It should be remembered that frequent applications of stable manure and other forms of humus essential to the successful production of greenhouse vegetable crops tend to lighten the soil, and the original selection should be made with this factor in mind. To produce lettuce of good quality a congenial environment is essential, including a soil of excellent physical condition and well supplied with readily available plant food, so that a rapid and uninterrupted growth can be made. It is undoubtedly true that the methods followed in handling the soil are of more importance than its original character.

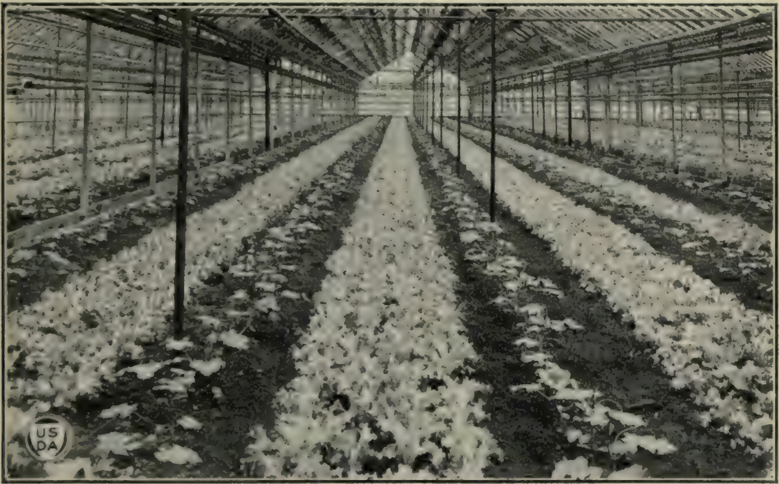

Fig. 3.—Lettuce grown as an intercrop between rows of cucumbers in a greenhouse. The lettuce is removed before the cucumbers reach the bearing stage

A thoroughly fined seed bed is requisite for the production of a successful crop of lettuce. The plants are small and delicate when set in the houses, and unless the ground is free from lumps it is impossible to set them in such a manner that they will make a quick recovery from transplanting and have a free and unrestricted root development. Because the root system of a lettuce plant is more extensive than is generally supposed, it is desirable that the preparation of the ground extend to a depth of 7 to 10 inches, thus giving room for root development and promoting the aeration and drainage so essential to the securing of a good crop.

The work of preparing the seed bed is done by hand with such tools as a spading fork, spade, and rake, particularly when small houses with ground beds or larger houses fitted with raised benches are used. Where cheap labor can be secured, the hand preparation of the soil is a good practice. In many cases the crop is harvested in the morning and a new one planted in the afternoon. Plowing and harrowing the ground in the houses with the aid of horse or tractor drawn tools have much to recommend them, especially where large areas are to be handled. Whatever the method followed in preparing the seed bed, it should be thorough in every particular.

MANURE, FERTILIZERS, AND LIME FOR GREENHOUSE LETTUCE

MANURE

Manure has always been the main dependence of the grower of greenhouse lettuce, and abundant supplies have made it unnecessary to resort to the use of other forms of organic matter and plant food. Many growers now find it difficult to secure supplies of manure sufficient to maintain the fertility of the soil in their houses at reasonable cost and are becoming more and more dependent upon other sources of organic matter and plant food. A certain amount of manure is desirable in the production of all vegetable-forcing crops. In cases where growers find it impossible to obtain supplies from their former sources, they have resorted to the use of manure from stock farms or from dairies, maintained largely for the purpose of assuring them a satisfactory supply. Where it is possible to secure as much manure as can be used to advantage, it is customary at the beginning of the crop season to apply about a ton to each thousand square feet of space, supplementing it by later applications made between crops. In the large vegetable houses without raised benches the manure is usually distributed by a team attached to a dump wagon or a manure spreader.

COMMERCIAL FERTILIZER

Heavy yields of high-grade lettuce can be obtained only when the crop is supplied with an abundance of readily available plant food. Many growers make a practice of applying a good general fertilizer, such as a mixture containing 4 per cent nitrogen, 8 per cent phosphoric acid, and 4 per cent potash, at the rate of 1,000 to 2,000 pounds per acre at the time the soil is prepared for the crop. Later applications of nitrate of soda, sulphate of ammonia, hardwood ashes, etc., are sometimes made, but as lettuce occupies the ground for a very short period these must be applied while the plants are small. Chemical fertilizers can be used only in moderate quantity, as heavy applications are liable to injure the plants. Many growers prefer to apply the nitrogen in the form of dried blood, tankage, fish scrap, or some other organic form, believing that there is less danger of injuring the lettuce through the use of such materials. Nitrate of soda and sulphate of ammonia used as a side dressing should be employed at a rate not exceeding 200 pounds per acre for each crop. Phosphoric acid from bone is preferred by most growers, but there is little to be gained from the use of this element after the lettuce plants are set, the logical time to use plant food bearing materials being when the ground is prepared.

Potash may be used in the form of commercial muriate or some of the other chemical forms, but as these, too, are slow in acting they are usually best applied before the crop is planted. Hardwood ashes constitute a desirable source of potash for greenhouse lettuce, the proportion contained depending on the source of the material and on the methods followed in handling and caring for it. A good grade of hardwood ashes may have from 5 to 6 per cent of potash, but the average is much less. These ashes also contain considerable lime, and where the soil needs this element they are especially valuable, usually being applied broadcast before the crop is planted. If they can be secured at reasonable cost, applications of 1 to 2 tons per acre may be made with profit, the value of the material depending on the percentage of potash and lime it contains.

LIME

Lettuce is very sensitive to an acid soil, and frequent applications of lime are necessary to keep most greenhouse soils in a suitable condition to produce the crop. The best growers make a practice of using lime at least once each season, just before preparing the soil for the first crop in the autumn. Ground limestone, ground burned lime, or ground hydrated lime may be employed. Ground limestone is supposed to be slower in its action than burned lime, but where annual applications are made it probably acts with sufficient rapidity to keep the soil well supplied with acid-neutralizing ingredients. Applications of 1 to 2 tons per acre of burned lime or about twice these quantities of ground limestone are usually considered ample.

VARIETIES AND SEED

Three classes of lettuce are used for forcing in the greenhouses. The heading sorts are largely grown in the Eastern States, but growers throughout other forcing regions are devoting more and more attention to the growing of varieties of head lettuce, as most markets prefer them. Loose-leaf lettuce is grown to a great extent in the Middle West, but producers are finding it increasingly difficult to dispose of the crop and are being compelled to devote more attention to the heading sorts. This condition is largely due to competition from head lettuce grown out of doors in the warm portions of the country.

Cos or Romaine lettuce is not produced to any great extent in greenhouses, although there seems to be an increasing demand for this type. Figure 4 shows specimen plants of representative varieties of the three classes, *A* being Grand Rapids, a loose-leaf lettuce; *B* Giant White Cos, representative of the Romaine type; and *C* Big Boston, a heading sort.

VARIETIES

Of the heading sorts May King and Boston Market are varieties widely grown. In the region of Boston, where the greenhouse head-

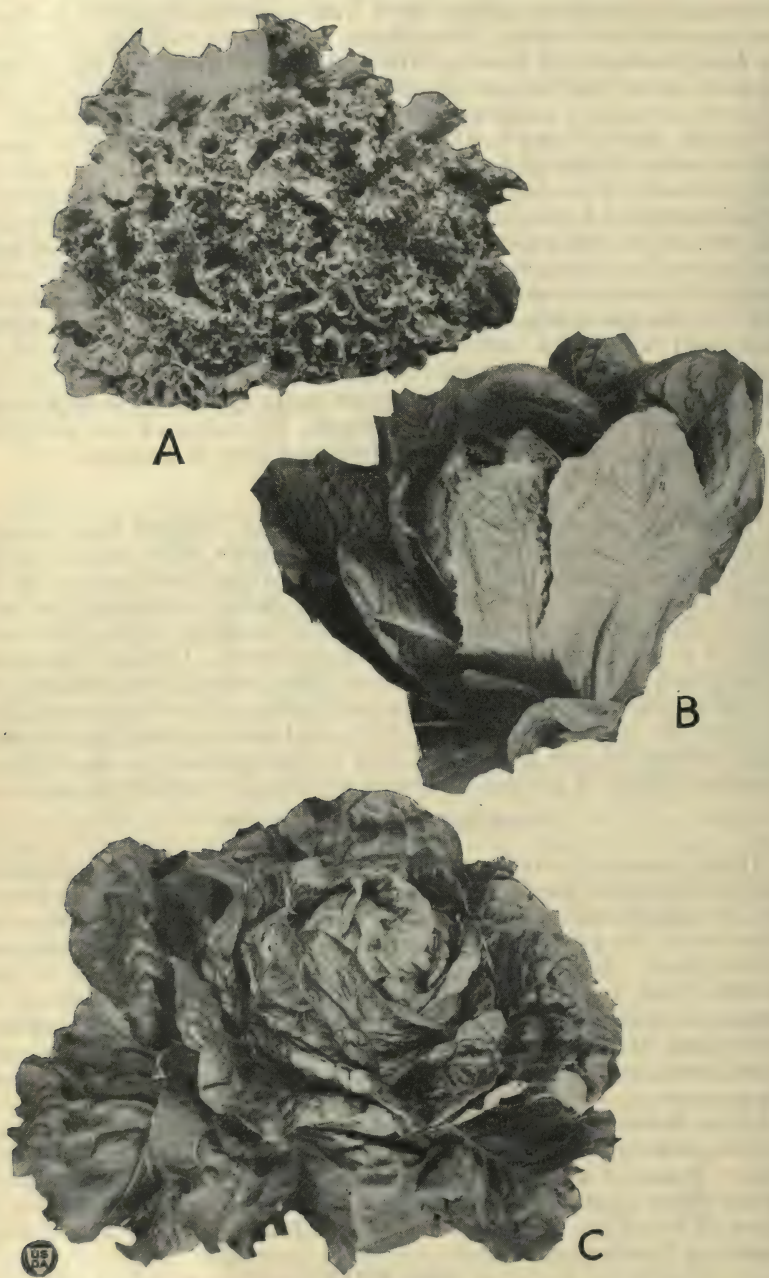

FIG. 4.—Heads of three classes of lettuce grown in greenhouses: A, Loose leaf; B, Cos or Romaine; C, heading

lettuce industry is developed to a greater extent than in any other greenhouse section in the United States, May King and Hothouse (Belmont) are grown to the practical exclusion of all others. Big Boston and Salamander are varieties also employed for forcing work.

Practically all the loose-leaf lettuce grown in greenhouses in the United States is of the Grand Rapids variety. This sort originated at Grand Rapids, Mich., and is said to be a cross between Hanson, a heading variety, and an unknown sort. There are several distinct strains of the Grand Rapids variety. The Ohio Agricultural Experiment Station, at Wooster, Ohio, has done considerable work in the development of special forcing sorts of lettuce and has obtained some superior strains of this variety. Work of the same nature has been carried on by the United States Department of Agriculture at the Arlington Experiment Farm, Va., reference to which will be made in a later portion of this bulletin.

Giant White Cos, Trianon, and Dwarf White Heart are varieties of Cos or Romaine lettuce frequently grown under glass.

SEED

Irrespective of the variety grown, the seed should be of a strain especially adapted to forcing work and to the conditions found in the greenhouses where the crop is to be produced. Commercial supplies of such seed are limited, and many growers have found it advantageous to grow their own supply, as it does not require much greenhouse space to produce sufficient lettuce seed to plant a considerable area. According to observations made at the Arlington Experiment Farm, from 60 to 100 plants of Grand Rapids lettuce will produce a pound of seed. The number of seeds of different varieties of lettuce contained in an ounce and a pound are shown in Table 1.

TABLE 1.—*Number of seeds per ounce and per pound of given varieties of lettuce*

Variety	Seeds in an ounce	Seeds in a pound	Variety	Seeds in an ounce	Seeds in a pound
Grand Rapids	27, 556	440, 896	May King	22, 453	359, 248
Salamander	24, 742	395, 872	Giant White Cos	22, 396	358, 336

A pound of good lettuce seed should supply enough plants to set an acre, but in practice, growers find it necessary to sow greater quanties, to allow for poor germination, loss of plants, etc.

The production of lettuce seed by the greenhouse owner in the houses where the main crop is to be grown makes it possible to develop a strain suited to his needs and, by continuing this strain, to assure himself that his crop will always be uniform. The procedure usually followed is to select a few plants of the desired type in the main crop and transfer them to pots when the main portion of the crop is harvested, so they can be carried to the seed stage. The best time of the year to do this is during the late spring, so the seed can be ripened during the early summer. The selections should be ideal plants of the type and variety being grown. If it appears desirable during the seeding stages to discard any not measuring up to the ideal, no further attention should be paid to these, the efforts being concentrated on the more promising ones and the final selection narrowed down to not more than 10 or 15 plants. When the seed begins to ripen, the seed head should be inclosed in a sack of paper or thin muslin, and when the plant is practically dead the seed stalk should be severed and hung up to dry. The seed may be rubbed out by hand, each lot being preserved and planted separately. If well-developed plants have been saved there should be enough seed from each to plant a good-sized area. This planting should be in the commercial range, so that additional selections can be made and the remainder of the crop used for commercial purposes. With the crop from each of the selected plants growing side by side, it is an easy matter to determine which comes nearest to the desired type. Any considerable number of off-type plants is sufficient cause for the rejection of the lot in which they occur. The best lot should be used as the supply of stock plants for growing the seed supply for the entire range, and all plants not wanted for seed purposes should be removed and disposed of in the usual manner. It is a good plan to leave the plants selected for seed in the place where grown until the crop is harvested, and the number selected and lifted for seeding will be determined by the quantity of stock seed that it is desirable to produce. The stock seed supply should be replenished from year to year by a repetition of the methods used for its establishment. It is seldom advisable to attempt to select and move sufficient plants from the main crop for the production of the entire seed crop. A better practice is to establish the stock seed in this manner, using this to plant the seed crop in a separate house, because lettuce grown for seed purposes should have more room than is required for the commercial crop. With most varieties sufficient room will be given the seed plants if they are spaced 12 to 15 inches apart. Figure 5 shows a crop of greenhouse-grown Grand Rapids lettuce seed for forcing.

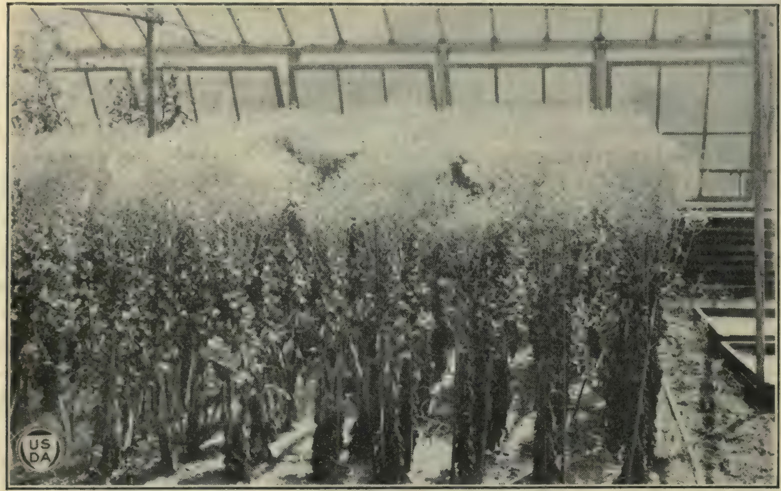

FIG. 5.—A seed crop of Grand Rapids lettuce grown in a greenhouse

SECURING LETTUCE PLANTS

Greenhouse lettuce is usually grown from plants started in a separate place and when of sufficient size transferred to the houses where the crop is to be matured. This practice economizes greenhouse space, as it is unnecessary to occupy this space with the crop during its early stages, when it can be cared for in a better manner in a separate inclosure, making it possible to secure a uniform stand in the growing house.

SOIL FOR LETTUCE PLANTS

Owing to the small size of lettuce seed and the delicate nature of the young plants, it is essential that the soil used for growing the plants be of a moderately loose and friable quality, free from lumps, and thoroughly screened so as to remove any clods, sticks, or stones. As little food is stored in the seed, the plant immediately throws out roots in search of nourishment, and if these come in contact with lumps or foreign matter the plant is liable to be dwarfed. A good soil for the production of lettuce may be prepared by composting 2 parts of sod and 1 part of well-rotted horse or cattle manure.

If the soil used for making the compost does not contain a considerable proportion of sand, it is a good plan to add some sand to this material. The compost pile should be prepared several months before the soil is needed, cut down, and turned once or twice before it is used for growing the plants. If the manure used for the compost is not of the best quality, it is well to add a few pounds of good mixed fertilizer to each ton of the compost. Many growers make a practice of using either raw rock phosphate, acid phosphate, or preferably bone meal, mixing it with the compost when the pile is turned for the first time; from 2 to 4 pounds of any of these to each ton of compost is usually sufficient. Other growers use manure to which applications of raw rock phosphate have been made in the stable. The main point to keep in mind is that lettuce plants require plenty of plant food and that it is better to apply this to the soil before the plants are started, so that they can make a rapid growth unhampered by lack of food. The screening can well be done at the time the soil is turned for the last time. Soil prepared according to these suggestions as a rule will give good results in the starting and growing of lettuce plants. Soil prepared from materials which have not been used for growing lettuce or related crops should be safe from all such lettuce diseases, except nematodes, as are carried in the soil, but the best growers prefer to sterilize all soil used for the production of the plants. The sterilization is particularly necessary when the soil is liable to be infested by nematodes or damping-off fungi. The methods followed in accomplishing this are fully described in Farmers' Bulletin 1320, The Production of Cucumbers in Greenhouses.

TIME WHEN SEED SHOULD BE SOWN

Plants for early-fall and late-spring crops will grow in a shorter period than is required for those for midwinter crops. From three to six weeks are necessary for the production of plants from seed, depending on the season of the year and the size of the plants desired. From 7 to 12 days of the time are spent in the seed bed and the remainder in the pots, flats, or in the benches of the nursery house, where the plants are carried to the size needed for greenhouse use.

SOWING THE SEED

Lettuce seed may be sown broadcast or in drills. Flats, ground beds, or raised benches may be used for starting the seedlings. Sowing in drills is preferable, and seedlings started in regular greenhouse flats 12 inches wide, 24 inches long, and 3 inches deep, inside measurements, can be easily handled and cared for. The shallow furrows, spaced about 2 inches apart, are usually made with the edge of a lath, and the seed is placed in these drills with the aid of the flap of a seed packet. About 8 to 12 seeds to the inch is the rate of seeding usually followed. Leaf mold, muck, or a very light textured soil is used to cover the seed to a depth of not more than an eighth of an inch. The flats are then covered with burlap, sprinkled, and placed where they can be partly shaded, to prevent their drying out too rapidly. The burlap is removed when the plants begin to come up. A temperature of 60° to 70° F. is satisfactory until the plants come through the ground, after which it should be reduced to prevent a too rapid, spindling growth. Care must be taken not to overwater the seedlings, as too much water induces damping-off and may also cause weak, spindling plants.

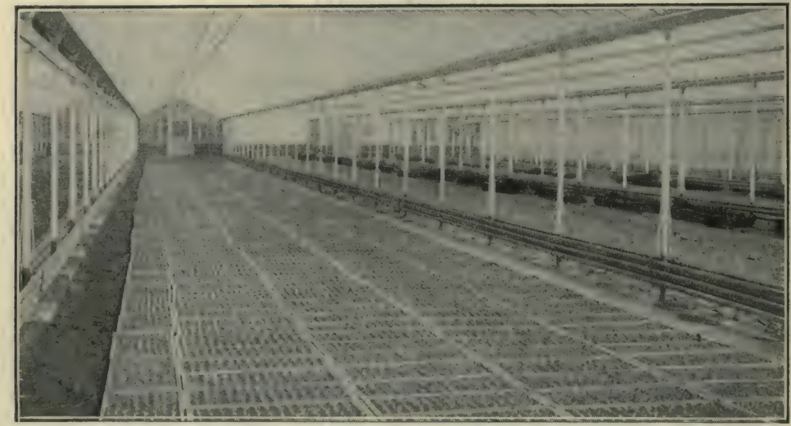

FIG. 6.—A lettuce plant house. Plants for a 10-acre range are produced in this house

TRANSPLANTING

Transplanted plants are usually stronger and more uniform, but the practice increases the cost of the crop. Many growers of loose-leaf lettuce do not transplant seedlings grown for the fall crop, while some do not transplant for later plantings. Transplanting is usually profitable for loose-leaf lettuce, especially for seedlings for the mid-winter and early-spring crops. Heading sorts are more particular in their requirements, and the plants are almost universally transplanted, some of the best growers transplanting them twice.

Transplanting takes place in a week to 12 days after seeding and is an operation requiring considerable care, as the young plants must be handled so as to avoid breaking and bruising. The soil must be uniformly firmed around the roots, or uneven growth will result. In some cases the seedlings are transplanted to paper bands or to pots, but the more common method is to shift them to the standard greenhouse flats, setting them about 2 inches apart each way, with from 70 to 100 plants in each flat.

After the plants have been transplanted they should be watered, using a fine sprinkler, and placed in a shaded house until they become established, a special greenhouse usually being set aside for plant growing. Figure 6 shows such a house occupied by lettuce plants. Great care is given to watering the plants, as they must not be allowed to dry out nor be oversupplied, as too much water will cause damping-off.

In large establishments, where planting and harvesting are going on continuously, it is necessary to make successive sowings of seed, so that a constant supply of plants will be assured. In many of these ranges the helpers used for this part of the work are kept constantly employed in transplanting, and as many as 5,000 plants each are transplanted in a day by those accustomed to the work.

ESTABLISHING THE CROP IN THE GREENHOUSE

PLANTING DISTANCES

Grand Rapids lettuce is usually set from 7 by 7 to 9 by 9 inches apart, but some growers set it 6 by 9, others 7 by 9 inches; it is probable, however, that more growers set it 8 by 8 inches than any other distance. The heading varieties, such as May King, Boston Market, and Salamander, are set from 7 by 7 to 8 by 8 inches apart, as most growers believe it is best to crowd them a little in order that a great number of moderate-sized heads may be produced. The number of plants required to set each 1,000 square feet and each acre of bed surface at varying distances is given in Table 2.

TABLE 2.—*Number of lettuce plants required per 1,000 square feet and per acre*

Distance apart	Plants for—		Distance apart	Plants for—	
	1,000 square feet	Acre		1,000 square feet	Acre
6 by 7 inches	3, 429	149, 368	7 by 8 inches	2, 571	111, 993
6 by 8 inches	3, 000	130, 680	7 by 9 inches	2, 286	99, 579
6 by 9 inches	2, 667	116, 175	8 by 8 inches	2, 250	98, 010
7 by 7 inches	2. 939	128, 023	8 by 9 inches	2, 000	87, 120

SETTING THE PLANTS IN THE HOUSES

The work of setting the plants is greatly expedited by using a device for making holes consisting of a wide board corresponding to the size and the shape of the beds and having wooden pegs about an inch and a half in diameter and 2 inches long inserted in rows at the proper distance for the plants. Figure 7 shows a marker of this description in use in a large range of ridge-and-furrow houses, where the board is of such length that it just reaches across the 12-foot beds. The board is set in the proper position for the first row of holes and pressed down, then removed to the correct position for the next rows and left there to serve as a working board for the planters while the plants are set in the holes already made, when it is again moved, exposing another set of holes, repeating the process until the entire area is covered. With large areas it may be necessary to plant in strips, as it would be impracticable to handle a marker more than 14 to 16 feet long. Other marking devices are used, but the type described is probably as satisfactory as any.

When grown in flats the plants may be easily transferred to the houses and distributed at suitable intervals. A knife run between the rows of plants separates them so that they can be lifted from the trays and set in position in the holes already made by the marker. Care should be exercised to firm the soil uniformly about each plant, and when in the ground they should be given a thorough wetting, using a fine spray to avoid injuring the young lettuce.

CARE OF THE CROP

TEMPERATURE AND VENTILATION

Lettuce is a cool crop, being ordinarily grown at temperatures of 45° to 50° F. through the night and some 10 degrees higher during the day. Its ability to thrive at such temperatures adds to its popularity as a midwinter crop. It must not be concluded that it is permissible to aid in maintaining these low temperatures by keeping the houses closed, as ventilation is extremely important, especially with head lettuce. Lettuce not supplied with an abundance of fresh air is likely to be soft, of poor quality, and more liable to drop, mildew, and tipburn than plants in a better environment. The best growers take the greatest care to give the crop proper ventilation without sudden fluctuations in temperature.

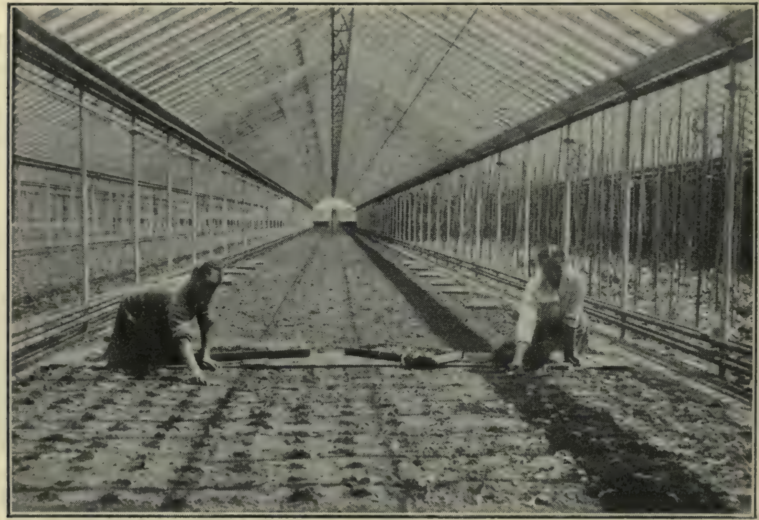

FIG. 7.—Setting lettuce plants in a greenhouse. The board shown serves as a marker and also as a support for the women doing the work

CULTIVATION

Proper preparation of the soil before the plants are set is the most important part of the cultivation of greenhouse lettuce. With a soil thoroughly prepared to a depth of several inches it is usually unnecessary to do more than maintain a very shallow soil mulch, using such tools as a hoe, scuffle hoe, or weeder. There is great danger that the roots may be disturbed through too deep cultivation. In houses where the walks are only a few feet apart the center area can be cultivated by workmen standing on them and using ordinary garden tools. In other cases boards resting on low trestles are placed across the beds, so that the workmen can reach the middle of the beds from these. Cultivation ceases when the plants begin to cover the ground.

WATERING

Lettuce requires considerable quantities of water, but great care must be taken to apply it in a manner that will not induce such diseases as drop and mildew. Most growers water the crop rather freely during the early stages of its growth, so that a good reserve of moisture is secured for its later development, when the application of water is attended with more risk. After the crop covers the ground, obstructing the free circulation of the air around the plants, the danger from overapplications of water becomes greater, but this should not deter growers from supplying the lettuce with sufficient moisture for its best development. The best growers make a practice of watering during the forenoon, for there seems to be a great deal of risk incident to the application of water during the evening, when the plants can not dry off before nightfall.

The methods of applying water determine to a great extent the quality of the crop. Lettuce is a tender vegetable that can not withstand heavy spray; consequently the watering must be carried on with exacting care, for applying it with a hose not fitted with a fine spray may ruin a good prospective crop.

Subirrigation, or the application of water through lines of drainage tile buried in the soil, is a method of watering greenhouse crops that is worthy of far more attention than it has received. Experimental work carried on several years ago at the Ohio Agricultural Experiment Station and by others showed that subirrigation gives excellent results in growing greenhouse lettuce. By running the water into lines of tile it is possible to saturate the soil without wetting the foliage; moreover, some growers make a practice of applying dilute liquid manure or solutions of nitrate of soda through these same lines.

Overhead irrigation systems are very extensively employed for the growing of greenhouse lettuce. Lines of pipe with nozzles inserted every few inches are installed on the posts supporting the roof or gutters of the houses, the locations being determined by the width and type of the structure, one line of pipe to every 40 or 50 feet as a rule being sufficient if so located that a uniform distribution of the water is secured. In the ridge-and-furrow type houses of moderate width a common plan is to place an irrigating line on the posts supporting the gutters, one line to every alternate house and so arranged that the pipe can be swung to water one side, then the other, movement being made possible by a swing joint near the end of the line. Such a system enables the operator to water his crop with the minimum of labor, insures him a uniform distribution of the water, and removes danger of injury through violent dashing, as the water coming from the nozzles of the overhead system in the form of a fine spray usually takes the temperature of the air before striking the plants.

HARVESTING AND PACKING

From 9 to 14 weeks are required from the time the plants are set in the houses until the crop is ready to harvest, but the length of the period is determined by the season of the year and the size of the plants when they are harvested, a shorter time being required in fall and spring than in midwinter. No specific rule can be given to determine the best time for harvesting the crop. With the heading sorts the heads must be well formed with well-bleached centers, but the cutting of the crop must not be delayed until rotting begins, as the lettuce becomes bitter and tough through age. The grower usually wishes to secure a maximum growth, but if prices are particularly favorable a smaller yield may give a larger return. If tipburn or other similar troubles appear it may be necessary to hasten the harvesting of the crop. If loose-leaf lettuce is cut when the plants have made their maximum development but before they begin to lose in quality, it will usually remain in marketable condition over a longer period than the heading sorts. Cos lettuce is ready for harvesting when the hearts are well filled with blanched leaves. Figure 4, *B*, shows a head of Cos in prime condition for market.

Butcher knives are usually employed for cutting the plants just above the surface of the soil. Some growers pack in the houses as the lettuce is cut, while others merely remove the discolored lower leaves and place the lettuce in containers for removal to the packing house. Figure 8 shows a harvesting scene in a range where the lettuce is roughly trimmed when cut, placed in bushel baskets, and transferred to the packing shed, where it is trimmed, washed, and packed in paper-lined barrels. Figure 9 illustrates the methods used in handling the lettuce. Round stave baskets, splint baskets holding from 3 to 6 pounds of lettuce, and other containers are employed for shipping the crop. Figure 10 shows the tubs used for washing the lettuce as it is harvested and the sugar barrels, holding 90 pounds of lettuce, used as shipping packages in a range where the crop is packed as cut. When apple barrels are used, 60 pounds of lettuce are packed in each. When filled the barrels are transferred to the shipping room, covered with burlap, and immersed in water for a few minutes, holes being bored in the bottoms to facilitate drainage.

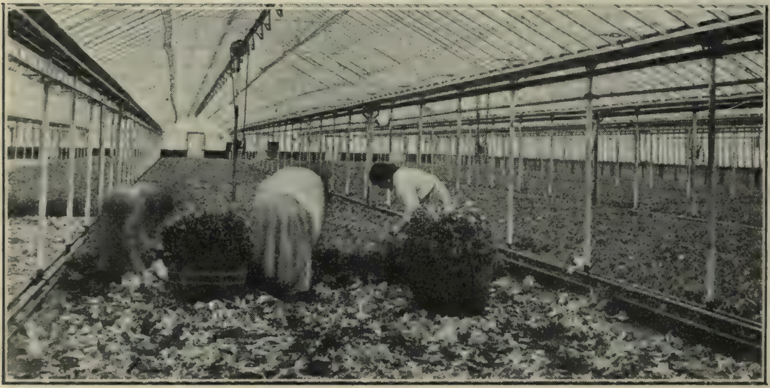

FIG. 8.—Harvesting loose-leaf lettuce. The plants are cut just above the soil, roughly trimmed, and packed in baskets for transferring to the packing shed

Head lettuce is handled in much the same way as the loose-leaf sorts. Most growers cut the lettuce and transfer it to the packing house, where it is trimmed and packed without washing or is washed by taking a head in both hands with the outer leaves pressed around the head and immersed in water once or twice, after which it is placed in the shipping package with the root end up. Bushel baskets holding from 2 to 3 dozen heads, half bushel or bushel hampers, crates holding from 2½ to 4 dozen, bushel boxes, or other containers are used. The marketing of greenhouse lettuce would be simplified by the adoption of standard containers.

Cos lettuce is handled in much the same way and in the same kind of packages as head lettuce.

As some water is necessary to keep lettuce from withering while in transit, the quantity adhering to it when washed seems to be sufficient, but when barrels or other containers immersed in water after packing are used, care should be taken to provide proper drainage.

Lettuce freezes at about 31° F., and when shipped in cold weather it must be well protected or serious losses may result. Paper lining the packages affords considerable protection, but in hard freezing weather much care must be taken to prevent injury to the crop while in transit.

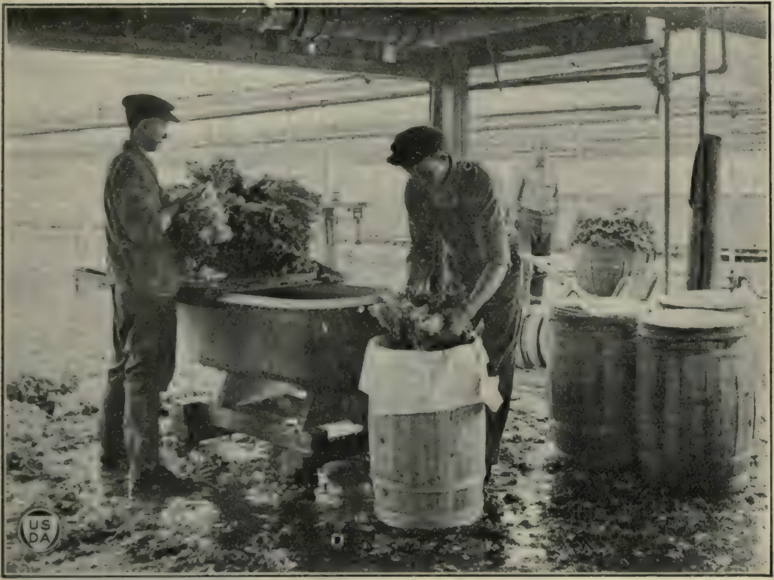

FIG. 9.—Washing and packing loose-leaf lettuce

STORAGE

Artificial cold storage is sometimes employed for keeping lettuce for short periods, usually to avoid marketing during periods of low prices. Work carried on at the Arlington Experiment Farm, Va., shows that Big Boston head lettuce stored at a temperature of 34° F. may be kept in good condition for about three weeks.

YIELDS OF GREENHOUSE LETTUCE

The yield of greenhouse lettuce depends on the vigor of the crop and its stage of maturity when cut; if harvested early the yield may be materially reduced. Of loose-leaf lettuce a crop of from three-fourths of a pound to 1 pound per square foot of bed is usually obtained, but many growers secure much larger yields. The strains of Grand Rapids lettuce produced at the Arlington Experiment Farm have repeatedly yielded a pound and a half per square foot, individual plants weighing over a pound being common. Head lettuce gives about the same yields as the loose-leaf sorts, with plants weighing from one-half to 1 pound each. Yields of Cos lettuce are similar to those of other sorts.

A pound per square foot of bed means a yield of over 20 tons per acre, and although the price per pound may be rather low the return per acre is high. The conclusion should not be drawn that the production of greenhouse lettuce is always profitable, because it is expensive to maintain greenhouse acreage and the gross returns must be large. It is impossible to make a general statement in dollars and cents of the cost of growing greenhouse lettuce. Such factors as interest on the investment, depreciation on the houses, management, fuel, labor, supplies, and selling expenses are important, but with a properly located range and a high-grade crop greenhouse lettuce should prove profitable.

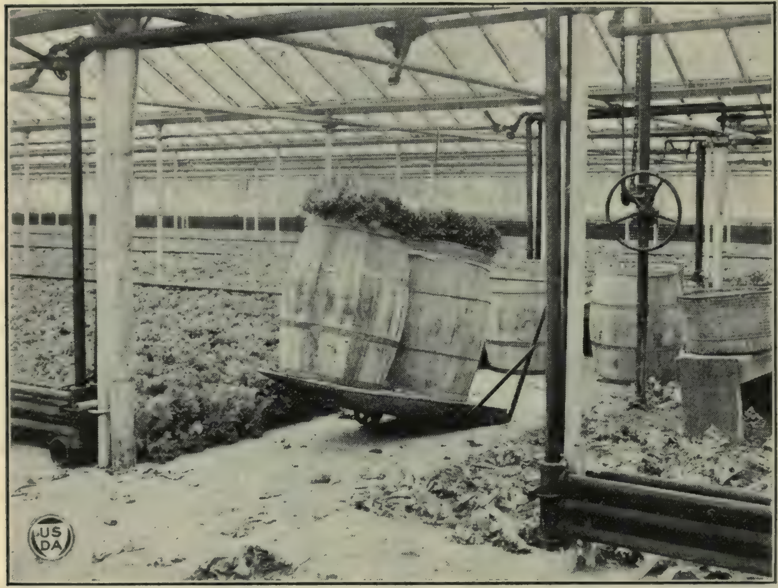

FIG. 10.—Packing lettuce in a greenhouse near the location where it was grown

DISEASES AFFECTING GREENHOUSE LETTUCE[1]

DROP

Lettuce drop[2] is possibly the most serious disease affecting the crop in the greenhouse. It is characterized at first by a wilting of the outside leaves, usually rapidly followed by the wilting and collapse of the entire plant. Affected plants show a soft watery rot of the stems and leaves near the surface of the soil, which decayed parts are usually covered by conspicuous cottony white wefts of fungus or mold in which are developed black seedlike fungous bodies.

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[1] Prepared by Ivan C. Jagger, Pathologist, Office of Cotton, Truck, and Forage Crop Disease Investigations.

[2] Caused by *Sclerotinia libertiana* Fckl. and *S. minor* Jagger.

The disease is particularly liable to cause trouble during damp, cloudy weather. Too high temperature, improper ventilation, overwatering the crop, and crowding the plants in the beds tend to increase the ravages of the disease. Proper management of the crop, especially the sparing use of water during the three or four weeks preceding harvest, tends to hold the disease in check. It is advisable that diseased plants, including taproots and surrounding soil, be removed and destroyed as soon as evident, in order to check the spread of the disease to adjacent plants and prevent the formation of the seedlike fungous resting bodies mentioned above, which remain in the soil and produce the disease in succeeding crops. Where the drop causes heavy losses, a practicable and very effective remedy is the sterilization of the soil, preferably by steam,[3] although under some conditions hot water[4] or formaldehyde may be used to good advantage. The use of fresh soil serves the same purpose as soil sterilization when one can be sure of obtaining disease-free soil.

BOTTOM-ROT.

Bottom-rot[5] is destructive in some sections, especially on heading varieties of lettuce, which grow with the outer leaves resting on the ground. The disease is characterized by a brown soft rot of the leaves, beginning where they rest on the ground and extending into the head. It is distinguished from drop by the absence of white wefts of mold and by the fact that the stem of the plant is not rotted. It is favored by moisture and can often be satisfactorily controlled by care in watering, especially by using no more water than is essential for the growth of the crop after the plants begin to shade the ground. When this treatment is not effective it is necessary to resort to soil sterilization, as for drop.

GRAY MOLD

Gray mold[6] attacks only plants which are already affected by other diseases or much weakened by unfavorable growing conditions. It causes a brown soft rot, and in advanced stages affected parts are covered with a grayish mold or fungous growth. It often follows tipburn, starting in the brown dead leaf margins. Trouble from gray mold need not be feared where the crop is so managed that strong, vigorous growth without tipburn is obtained.

MILDEW

Lettuce mildew[7] is characterized by yellowish or brownish spots in the outer leaves, covered on the lower and sometimes on the upper surface by a white fuzzy mildew. Insufficient ventilation, overwatering, and fluctuating temperatures are liable to induce trouble from this disease. Careful management of the houses and the crop as a rule is effective in controlling it. For further information on this disease, consult Bulletin 196 of the Iowa Agricultural Experiment Station, Controlling Downy Mildew of Lettuce.

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[3] See Farmers' Bulletin 1320, The Production of Cucumbers in Greenhouses.

[4] See U. S. Department of Agriculture Bulletin 818, Soil Disinfection with Hot Water to Control the Root-Knot Nematode and Parasitic Soil Fungi.

[5] Caused by *Rhizoctonia* sp.

[6] Caused by *Botrytis vulgaris* Fr.

[7] Caused by *Bremia lactucae* Reg.

ROSETTE

Rosette causes considerable loss to lettuce growers. The disease is caused by a fungus[8] which lives on the roots, interfering with the nutrition of the plants and resulting in dwarfed, stunted heads. It is often induced by improper setting, faulty fertilization, or poor soil conditions.

TIPBURN

Head lettuce, and to a less extent leaf lettuce, is subject to tipburn, or a dying and browning of the margins of the leaves making up the central portion of the plant. The primary cause of the disease is too high temperature, although an excessive amount of nitrogenous fertilizers, especially when there is a deficiency of other fertilizer elements, makes crops more susceptible. Tipburn is usually the result of a few days of dark, cloudy weather, during which the houses are run at rather high temperatures with little or no ventilation, resulting in a rapid watery growth. On a change to sunny, dry weather the soft watery growth loses moisture so rapidly that the leaf margins are killed. Somewhat lower temperatures than normal and adequate ventilation during dark, cloudy weather should prevent tipburn during the winter. Where outside temperatures are too high during the fall and spring, care in fertilizing, watering, and ventilating to obtain as solid and firm a growth as possible helps to hold the disease in check.

ROOT-KNOT

Root-knot[9] has never been considered particularly destructive to greenhouse lettuce, but it must be controlled if the best results are to be secured. During the winter season lettuce houses are usually run at such a low temperature that the disease remains dormant and does no damage, but during the warmer weather of fall and spring root-knot may cause serious injury. It is very injurious to both cucumbers and tomatoes, and when one or both of these occupy a place in the greenhouse rotation it is especially desirable that the disease be controlled.

Steam sterilization of the soil is an effective control measure if carried out carefully and thoroughly. The microscopic eelworm causing this trouble works down to a depth of a foot or more and penetrates under walks and side walls. Satisfactory results can not be expected unless the soil is heated at a temperature of at least 212° F. to a depth of at least a foot. Complete directions for the sterilization of greenhouse soils are to be found in Farmers' Bulletin 1320, The Production of Cucumbers in Greenhouses.

INSECTS INJURIOUS TO GREENHOUSE LETTUCE[10]

Lettuce grown in the greenhouse is subject to injury by several insect pests. The most troublesome are plant lice and the white fly, which frequently cause serious damage unless they are checked. The cabbage looper and cutworms occasionally gain entrance to greenhouses and do considerable injury.

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[8] *Rhizoctonia* sp.

[9] Caused by the eelworm *Heterodera radicicola* (Greef) Müller. See Farmers' Bulletin 1345, Root-Knot: Its Cause and Control.

[10] Prepared by W. H. White, Entomologist, Truck Crop Insect Investigations, Bureau of Entomology.

PLANT LICE AND THE WHITE FLY

HYDROCYANIC-ACID GAS FUMIGATION

The most effective and cheapest method to rid vegetable houses of the white fly and plant lice is by fumigation with hydrocyanic-acid gas. This gas is exceedingly poisonous, and serious injury to the plants and the operator may result if care is not exercised in handling it, but in competent hands it is a safe, practical, and economical fumigant.

The gas is generated from sodium cyanid and dilute sulphuric acid, the chemicals being used in the following proportions:

Sodium cyanid	ounce	1
Sulphuric acid (approximately 93 per cent pure)	fluid ounces	1½
Water	do	3

Glass or earthenware jars are used as generators. The chemicals should always be mixed in the following order: The required quantity of water is placed in the generator first and to this is slowly added the proper proportion of sulphuric acid. When arrangements for the fumigation are complete, the sodium cyanid, which has been wrapped in light paper or paper bags, should be dropped into the generator, care being taken to avoid spattering. The poisonous hydrocyanic-acid gas is generated as soon as the cyanid comes in contact with the dilute acid. In practice, therefore, the operator must start with the generator farthest from the exit and drop the cyanid into the jars as he moves toward the door. Do not tarry between generators, and leave the house as soon as the cyanid has been dropped into the last generator.

Fumigation should be conducted at night, as the gas seriously injures plant tissue in the presence of sunlight. Since tender growing plants are very susceptible to injury from hydrocyanic-acid gas, the dosage should be carefully and accurately calculated.

In the fumigation of lettuce for the control of the white fly and plant lice, one-fourth ounce of sodium cyanid should be used for each 1,000 cubic feet of air space contained in the house. The plants should be exposed to the gas overnight, the fumigation beginning not earlier than half an hour before darkness and the house being ventilated not later than half an hour after sunrise. The dosage suggested above will kill plant lice and adult white flies, but since the immature stages of the latter insect are not killed so readily, it is often necessary to repeat fumigations about every 10 days in order to insure the control of the white fly.

While fumigation with this chemical is relatively simple, inexperienced persons should not attempt the use of hydrocyanic-acid gas without definite knowledge of the proper methods of applying the materials.

For detailed information on the use of hydrocyanic-acid gas, consult Farmers' Bulletin 880, Fumigation of Ornamental Greenhouse Plants with Hydrocyanic-Acid Gas.

NICOTINE FUMIGATION

Fumigation with nicotine is used extensively and with effective results for the control of plant lice infesting greenhouse crops. This method, while convenient, is usually more expensive than hydrocyanic-acid gas fumigation. The nicotine is made available either by burning tobacco stems, specially prepared paper treated with nicotine, or finely ground tobacco dust, or by vaporizing liquids containing nicotine on special burners or hot steam pipes.

When stems are used they are burned in ash cans or similar containers, placed at intervals of 40 to 50 feet throughout the houses, and usually suspended by wires from the frame of the houses so that the heat will not injure the crop. A bushel of stems is sufficient for each 200 to 300 square feet of greenhouse space. The stems should be so moistened that they will burn slowly and produce a dense smoke that will fill all parts of the house. Fumigation is always conducted at night or on cloudy days, taking care that the plants are dry; otherwise injury may result.

Nicotine papers, tobacco dusts, and tobacco or nicotine liquids prepared for fumigating purposes contain variable proportions of nicotine, and it is advisable to follow directions for their use as given by the manufacturers. The grower is advised to observe carefully the results obtained and if the fumigation is not effective to increase the quantity of material.

THE CABBAGE LOOPER

The cabbage looper, one of the " worms " commonly found on cabbage, often gains entrance to greenhouses by being inadvertently carried there; or the moth may enter the house in late fall and deposit eggs upon lettuce or other available food plants.

When attacked by worms, the immature lettuce may be sprayed with lead arsenate at the rate of 1½ pounds to 50 gallons of water. To avoid all chance of arsenical poisoning of the consumer, the last spray should be applied not later than one month before the crop is harvested. If the insects are successfully controlled during the first outbreak, there will be little danger of their recurrence.

CUTWORMS

Cutworms occasionally cause considerable damage to young lettuce. They usually gain access to the greenhouse by being transported in the soil, or the moth may enter the house late in the season and deposit the eggs from which the worms develop. Cutworms may be controlled by the use of poisoned bait, prepared as follows:

White arsenic	pound	¼
Sirup or molasses	do	1
Dry bran	peck	1
Water	quarts	4 to 6

Thoroughly mix the arsenic with the bran and add the water and sirup while constantly stirring the mixture. Distribute the poisoned bran in small heaps late in the evening throughout the lettuce bed.

Sterilizing the soil will kill the cutworms contained therein.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1419

CARE AND MANAGEMENT OF FARM WORK HORSES

THE PROPER MANAGEMENT of farm work horses means that they must be so maintained as to be more serviceable, more profitable, and longer lived than the average horse.

Convenient stabling facilities save time and labor.

The farm work horse should be wintered economically, yet kept in thrifty condition.

A " fitting " period is essential in order that horses will be in condition for the heavy spring work.

Concentrated feed of good quality is necessary to supply energy for hard work.

Grooming improves the general appearance of the animal, and promotes proper functioning of body activities.

The collar and other parts of the harness should fit comfortably.

A man who has the ability to keep horses in good condition so that they are ready for any call is a good horseman.

Washington, D. C.

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CARE AND MANAGEMENT OF FARM WORK HORSES.

By J. O. Williams, *Senior Animal Husbandman in Horse and Mule Investigations, and* Earl B. Krantz, *Animal Husbandman, Animal Husbandry Division, Bureau of Animal Industry.*

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IMPROVEMENT NEEDED IN HORSE HUSBANDRY.

HORSES furnish power for so many operations on the farm that improvements in horse husbandry are desirable to reduce to a minimum the cost of this power. The farm work horse must be properly cared for, and efficiently managed, if the greatest net returns are to be realized.

There is comparatively little scientific information on which to base conclusions relating to the care and management of horses. This bulletin, however, will attempt to summarize the information that is known, and to suggest methods which experienced horsemen have found to be most satisfactory.

The management of farm work horses varies with the seasons. It requires judgment on the part of the owner to feed economically, and yet keep the horses in good physical condition, so that only a minimum number need be carried for the peak periods of work.

During the winter season, some owners feed too heavily, and others do not feed enough. Both of these extremes are to be avoided.

Many farm horses are poorly fitted and conditioned for the spring work, when the heaviest demands are made on them. This practice is costly, as the efficiency of the horses is impaired, and more are required to do the work. Fitting the horse for work means not only that he carries flesh enough, but also that his system is functioning properly, that his muscles are developed and hardened, and that his shoulders have been toughened for the heavy tasks ahead..

FACTORS INVOLVED IN CARE AND MANAGEMENT.

The question of effective farm power is a vital problem. The effectiveness and reliability of horse power are determined largely by the following: (1)The man responsible should have the ability to keep the horses in thrifty condition at all times; (2) convenient stabling adjoining the paddock and suitable sheds for wintering should be provided for the comfort and health of the animals; (3) feeding must be adjusted to seasonal requirements; (4) thorough, regular grooming is necessary; (5) the harness must be well fitted and cleaned regularly to insure satisfaction and durability; and (6) the shoulders, feet, and teeth must be well cared for.

THE HORSEMAN.

A fundamental factor in all problems of animal husbandry is the man. In no phase of animal husbandry is this "man" element more vital than in the care of horses. The horse responds readily to the understanding and intelligence of his caretaker, and the diligence of the master often forestalls some of the things which might incapacitate the horse when his services are most needed. The virtues in an ideal caretaker include: Fondness for horses; a kind, quiet, even-tempered disposition; regularity of habits; and close observation.

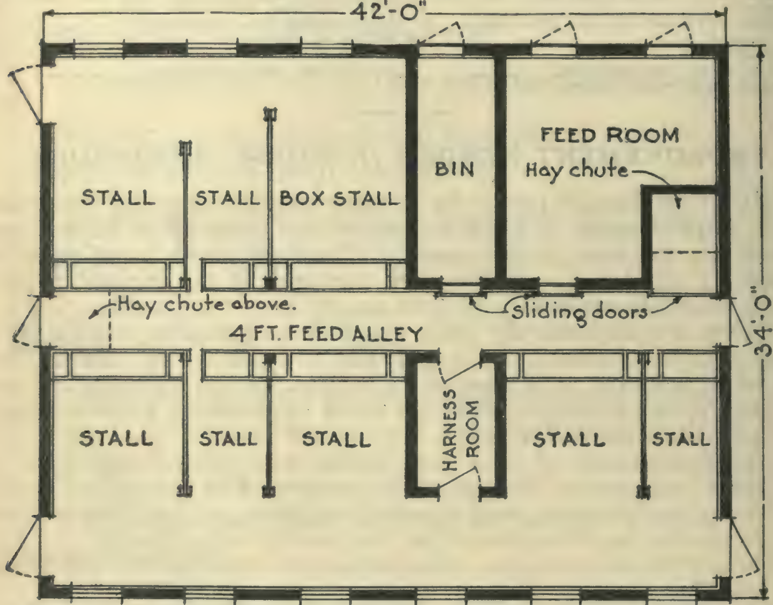

FIG. 1.—Convenient and compact stable for work horses. Complete plans and specifications may be obtained from the Bureau of Public Roads, United States Department of Agriculture, Washington, D. C.

When a man has the ability to keep horses in good condition so that they are ready when needed, he is a good horseman. Horsemen are spoken of as men having a "knack" for handling horses, understanding thoroughly every horse under their care, knowing how much feed is required, how much work can be accomplished in a day, and having the ability to detect warning signs of overwork, overheating, and disorders of all kinds.

STABLE, SHED, AND PADDOCK.

Much time is saved in the care of work horses if the stable is conveniently arranged so that the chores may be done quickly, and the feed, harness, and equipment are readily accessible. (See fig. 1.) A conveniently located harness room should be provided. By this arrangement many steps are saved and the life of the harness is prolonged. Common labor-saving appliances, such as carriers for manure, feed, and harness, are especially important in large stables. Although the box stall provides the greatest comfort, the open stall has been found satisfactory for work horses and requires less space. A good-sized single stall for a horse weighing about 1,400 pounds is 5 by 10 feet, but the stall should be wider for larger horses.

Abundance of light and proper ventilation of the stables are essential for complete sanitation and the health of the horse. Where windows are relied upon for both light and ventilation they should be high up from the floor, and open inwardly from the top. Ventilation[1] is required in winter as well as in summer: therefore a system with floor-outlet ventilators will tend to carry off foul air and regulate the temperature, especially in colder climates. In any system of ventilation it is important that the horses are not subjected to direct drafts.

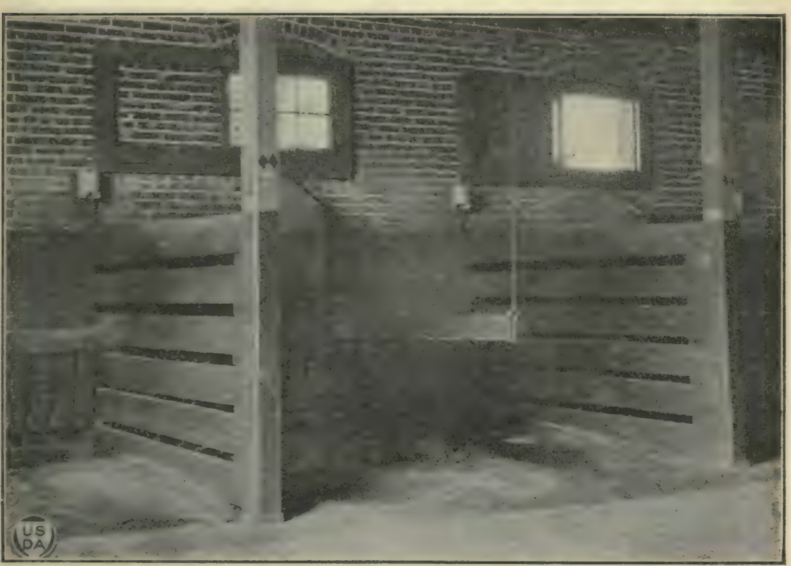

Fig. 2.—Double stall for work horses. Note the open partition, which permits free circulation of air, the slope of the clay floor, and the swinging pole. The bedding is thrown forward to the middle for sanitation.

Stalls must be well bedded, and cleaned daily, in order to keep them dry and sanitary. (See fig. 2.) Wet, mucky stalls predispose to the development of thrush and similar foot troubles. Many advantages are claimed by advocates of the various kinds of floors. Concrete floors with board surfacing in the stalls are preferred by many, as they are easily kept in sanitary condition. Clay, however, is undoubtedly the best material with which to make floors for horses, but such floors are objected to by many farmers because of the difficulty in keeping them level and clean. To be satisfactory, clay floors must be kept smooth, with slightly more slope for drainage than is required by other types of floors.

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[1] For the principles of ventilation, see Farmers' Bulletin 1342, Dairy Barn Construction.

A large paddock in connection with the stable helps considerably to keep in fit condition horses that are worked irregularly. A series of sodded lots will be found preferable, as, in addition to the exercise the horse gets, he will be benefited by the grass which acts as a tonic. Paddock exercise, though not as good as regular work, helps to guard against filled hocks, azoturia (so-called Monday morning sickness) and other troubles.

When horses are wintered largely in open fields, a dry shed with the open side away from the prevailing winds will generally afford a satisfactory shelter. Although horses that are "roughed" through the winter in this manner develop long, heavy coats of hair which protect them from the cold, it is a mistake to assume that their coats afford sufficient protection from storms. When horses are stabled at night the shed is usually not required.

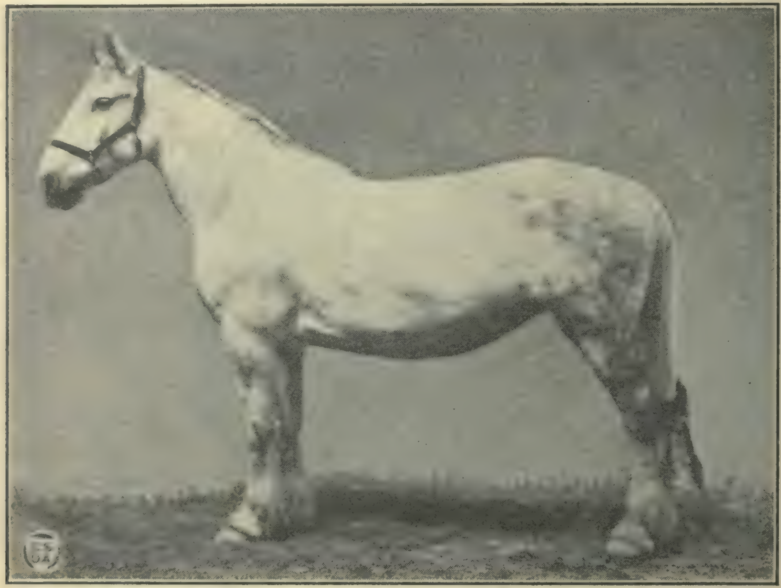

FIG. 3.—This deep-bodied, closely coupled, smoothly built mare keeps in good flesh on a small ration.

FEEDING FARM WORK HORSES.[2]

The most important factor in the care and management of farm work horses is feeding. Feeding methods vary in different parts of the country and with the different seasons. There is no definite standard for feeding all classes of horses, but there are certain basic rules which serve as a guide in feeding under varying work conditions. Regularity and care are of primary importance. Irregular feeding, or sudden changes in rations, frequently result in digestive disorders. Any change in the ration should be made gradually, because an immediate change in feeds—for example, from oats to corn, or from old hay to new hay—may result in colic. Care in all feeding operations is necessary for complete utilization of the feed and consequent fitness for work at all times.

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[2] For detailed information regarding the feeding of horses, the composition of feeds, and methods of computing rations, consult Farmers' Bulletin 1030, "Feeding Horses."

Trash or dirt must be removed from the grain box before each meal and chaff and refuse cleaned from the manger before the night feeding of hay. The feeder must also see to it that the feed used is of good grade. Musty, spoiled, or dirty feed may cause the horse to get "off feed" and not be fit for work.

Individuality has a special bearing on the feeding and management of work stock. (See figs. 3 and 4.) Some horses keep in good condition on a minimum ration, while others require much more than the average quantity of grain and hay. The same feeds are not relished by all horses, and all feeds do not have the same effect on all horses. It is necessary, therefore, to observe each horse closely and to substitute special feeds when necessary if the best results are to be obtained.

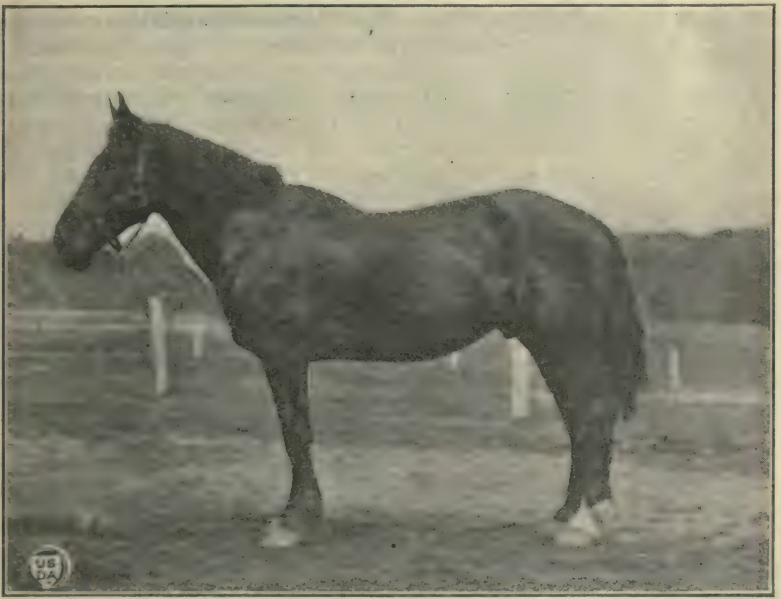

FIG. 4.—This shallow-bodied, loosely coupled horse, although smaller and on similar work, requires about one-fourth more grain daily than the mare shown in Figure 3.

FEEDING UNDER WORK CONDITIONS.

During the work season a horse should eat only at regular intervals. Concentrated feed is necessary to supply the energy for hard work. The use of large amounts of roughages during the work season should be limited to periods of rest. Excessive feeding of hay is a wasteful practice in many ways; it is expensive, reduces the efficiency of the horse, and often causes respiratory disorders. It is especially important that the grains and hay be of the highest quality at this time in order to obtain the greatest return in the form of work.

The selection of nutritious, high-grade feeds is as essential as the methods of feeding and management. Inasmuch as home-grown or locally grown crops generally constitute the most economical basis for the ration, the feed will vary with such crops. The most common feeds for horses are oats, corn, barley, and bran, together with timothy, prairie, clover, and alfalfa hays. In the West, the grain hays are popular, while in the South, Johnson grass is widely used. Of the concentrates, oats most nearly supply the requirements for work horses and, on account of the uniformly good results obtained from their use, have always been recognized as the leading grain for them. The other grains, also, are widely used, particularly corn. It is often possible, however, to make substitutions in the ration, resulting in a noticeable saving, without affecting its nutritive value. The nutritive value may also be increased without increasing its cost. Bran, particularly when corn or barley is fed with timothy and the coarser roughages, improves the ration. Bran is high in protein, mildly laxative in character, and has a cooling effect on the system. The limited use of alfalfa, clover, or other legumes with timothy or similar hay increases the nutritive value of the ration.

The amount of grain and hay required by the farm work horse depends, among other things, on the kind, regularity, and speed of the work performed. Although the exact amount is variable, a general guide is to allow $1\frac{1}{10}$ pounds of grain and $1\frac{1}{4}$ pounds of hay per 100 pounds live weight for horses at moderately heavy work; and $1\frac{1}{4}$ to $1\frac{1}{3}$ pounds of grain, with not to exceed $1\frac{1}{4}$ pounds of hay, at heavy work. The following table may be used as a guide in feeding:

TABLE 1.—*Average weight and measure of some common feeds.*

Feed.	One quart weighs.	One pound measures.
	Pounds.	*Quarts.*
Barley, steam rolled	0.6	1.6
Corn, shelled	1.7	.6
Corn, cracked	1.5	.7
Cowpeas	1.9	.5
Linseed meal, new process	.9	1.1
Linseed meal, old process	1.1	.9
Molasses (cane, blackstrap)	3.0	.3
Oats, whole	1.0	1.0
Oats, rolled	.5	1.9
Soybeans	1.8	.6
Wheat bran	.6	1.6
Cottonseed meal	1.0	1.0

The grain part of the ration for horses at work is usually divided into three equal feeds. If the horse does not clean up his grain in a reasonable length of time, the quantity should be reduced. About two-thirds of the daily hay allowance is given at night, with most of the remaining hay fed in the morning, leaving only a very small allowance for the noon feed. The quantity of roughage should be limited within the maximum allowance, so that all the edible forage will be cleaned up every day. When there is edible forage remaining from the night feeding, do not put in a fresh supply, but stir up that which is in the manger, so that the chaff goes to the bottom, leaving the good hay available. Some hay should be fed before the grain at night, for the appetite of the horse is not appeased by the grain when it is fed first, and he fills up on hay, forcing the grain on through the stomach too quickly, thereby decreasing the quantity assimilated.

The following daily rations (Table 2) are suggested as practical combinations and quantities of feed. As the rations suggested are for the average (1,000-pound) work horse, increase the ration by one-fifth, if the horse weighs 1,200 pounds, and by two-fifths if the horse weighs 1,400 pounds. For example, in the case of the first ration, a 1,400-pound horse should receive 15.4 pounds of oats, and 8.4 pounds each of timothy and alfalfa or clover. These rations are based on the theoretical requirement of horses at rather light work, such as cultivating corn. If the horses are at heavy work, such as plowing, the grain should be increased 15 to 20 per cent, the exact amount, of course, depending on the individual animal. When the 1,000-pound horse is on light work, he generally requires not more than 10 pounds of grain daily, and will probably keep in good condition on less.

TABLE 2.—*Daily rations for 1,000-pound horse at medium work.*

Ration 1.	Pounds.
Oats	11
Timothy hay	6
Clover, or alfalfa, hay	6
Ration 2.	
Oats	6
Corn, shelled	5
Timothy hay	6
Alfalfa, or clover, hay	6
Ration 3.	
Corn, shelled	8
Bran, wheat	2
Alfalfa hay	8
Timothy hay	4
Ration 4.	Pounds.
Barley, rolled	10
Alfalfa hay	6
Prairie, or timothy, hay	5
Ration 5.	
Corn, shelled	11
Cowpea hay	6
Johnson grass hay, or corn stover	6
Ration 6.	
Corn, shelled	10
Soybeans or cowpeas (ground)	1
Alfalfa hay	6
Corn stover	6

The method of feeding has a great deal to do with the utilization of the feed and the condition of the horse. Attention to the methods often results in increased utilization of the feed by the horse, and saving of feed. It is important that the horse that bolts his grain be made to eat slowly, which may be done by feeding the grain spread out in a large, flat box, by placing several smooth stones about 3 inches in diameter in the feed box, or by mixing it with bran, cut hay, or similar feed. Some horses waste their hay by pulling it out and trampling it underfoot. This is sometimes caused by feeding two kinds of hay, one of which is especially palatable. In that case, the waste may be corrected by feeding the hay so that the horse can eat the more palatable first. The horse will then eat the other hay leisurely during the night. Another plan is to withhold the good hay until the other is eaten.

Overfeeding, rather than underfeeding, is the common practice when horses are working irregularly. It should be remembered that the amount of feed should vary not only between winter and summer, but also from day to day. It is a waste of feed if the amount is not varied with the degree of work. When horses are to be idle on the following day, as on Sunday, it is well to substitute a bran mash for the Saturday-night grain feed, and reduce the grain feed for Sunday to approximately half of the normal ration. A mash is made by mixing 3 or 4 pounds of dry bran (per horse) with hot water, and allowing it to steam in a covered receptable until cool enough to eat. Do not cook or scald the bran by using water that is too hot. The palatability of the mash is increased by the addition of a tablespoon of salt per horse.

Pasture saves feed and labor and the grass acts as a laxative and a general tonic. While good pasture is sufficient for maintaining idle horses, a light supplementary grain ration, nonlaxative and relatively high in protein, is generally advisable for work horses. When horses that are accustomed to a heavy grain ration are turned on pasture for a long idle period, they should be given a small amount of grain for a few days; otherwise they may gorge themselves on the green roughage and suffer impaction, rupture of the stomach, or other serious trouble. When horses are laid off from field work for periods of only a few days at a time, the reduction in grain will depend somewhat on the feed value of the pasture, but generally the grain ration at this time should be about half the normal requirement. Irregularity, with sudden changes to green feed, is likely to result in digestive disorders. Turning the horses regularly on pasture at night is a means of keeping the digestive system accustomed to succulent feed. This practice decreases the quantity of hay needed by the horses, but they should receive a small feed of hay with the regular evening grain ration before being turned out. Horses that are turned on night pasture sweat more at work than horses on dry feed, but this is overbalanced by the benefits derived during hot weather, when the pasture provides a place to roll, water at will, and a clean, cool place to rest.

FIG. 5.—Grass acts as a general tonic to the system. Night pasture also provides a place to roll, water at will, and a clean, cool place to rest.

WATER.

There is quite a diversity of opinion among horsemen on the question of watering horses. Some feeders maintain that horses should always be watered before feeding, in order to prevent a flushing of the grain through the stomach into the small intestine. This system is not always practicable, however, as some animals refuse to drink before eating. The consensus of opinion on watering horses indicates that water may be given either before, during, or after meals without injurious effects. Thus, individual convenience and attendant circumstances will largely determine the watering practice to be followed. In any practice, however, it is well to adhere to the same plan, once a definite watering time has been adopted, for to change frequently from one system to another will affect the animal's appetite. Regularity in watering methods as well as in feeding methods should be adhered to.

The following factors should be considered in watering horses:

Horses which have been deprived of water for a long period or those which have undergone severe exertion should generally be watered before eating. It is dangerous, however, to allow an animal to drink heavily while very warm. If the horse is hot, give a moderate drink at this time, and water more freely after the animal has cooled off.

It is not a good practice to water heavily just before putting horses to heavy work.

Weather conditions, the nature of the work done, and the kind of feed consumed will determine the quantity of water required. In hot weather and when at hard work, horses consume more water than in cold weather or when inactive. Horses will drink more water when fed a protein-rich ration, such as alfalfa hay, than when on a carbonaceous diet.

The average water consumption per individual horse is from 10 to 12 gallons daily.

One of the times when a horse requires and appreciates a drink most is when it has finished its nightly allowance of roughage. Every horse should be allowed to drink at this time if possible.

It is better to water frequently, in small quantities, than to allow the animal to gorge itself at any one time.

Watering at public troughs is to be avoided, as this is a common method of spreading disease.

SALT.

Horses should be given salt at frequent, regular intervals, or, better, salt should be accessible at all times. When salt is given regularly, only enough to meet the body requirements will be consumed, while with irregular use an abnormal appetite develops for it, which, in turn, is often followed by an excessive consumption and digestive troubles if unlimited access is allowed. An average of about three-quarters of an ounce daily should be allowed under normal conditions. Horses doing heavy work, however, or those on dry feed will consume more than this quantity.

Aside from its value as a feeding requisite, salt is of benefit as an appetizer, for in many instances delicate eaters and shy drinkers will show an increased appetite when allowed free and regular access to it.

WINTERING IDLE HORSES.

Maintaining the farm work horse in healthful condition during the winter is the first start in fitting him for spring work. The horse should not be so fed during the winter that he becomes fat and soft. On the other hand, poor care during the winter, resulting in loss of weight and vitality, so weakens the horse that he is not in condition for spring work, and often his resistance is so lowered as to invite disease.

It is bad management to let a horse lose weight during the winter and then try to bring him back to normal by heavy feeding just before the beginning of spring work. If, however, the horse is thin or run down at the beginning of winter, he should be gradually brought into thrifty physical condition. Winter and early spring feeding should so strengthen the horse that he will be ready for the fitting period and heavy spring work.

The liberal use of roughage, supplemented with the right amount and kind of other nutritious feed, will maintain a horse properly during the winter. Farm horses, except brood mares or growing stock, do well on a ration made up largely of the coarser hays, straw, or corn fodder. Cornstalk fields, grain-stubble fields, or pastures which have not been closely grazed during the summer are very desirable sources of a large part of the winter maintenance feed for horses. The common roughages, as the main part of the ration during this period, will supply enough bulky feed to keep the horse thrifty without putting on superfluous fat. The drinking of a large amount of pure water should be encouraged to increase the utilization of these dry roughages. When necessary, a tank heater should be used to keep the drinking trough free from ice.

It is advisable to supplement the coarser roughages with a legume, such as alfalfa, clover, vetch, soybean, or cowpea hay. These hays are very palatable and should be fed sparingly. They are rich in protein and mineral matter and supply the materials needed to replace those lost in the natural wear of the body. Being somewhat laxative in effect they also help to keep the digestive tract in good condition. They are especially valuable in connection with straw and similar feed. The use of these hays with the coarser roughages is economical because a supplemental ration of grain is not necessary.

Corn silage, if fed with care, may be utilized in limited amounts in the winter ration of idle work horses. It is generally considered that the amount of corn silage should not exceed 10 pounds daily. Corn silage is bulky, appetizing, succulent, and slightly laxative. None but choice, fresh silage should be given to horses. Severe losses from botulism (forage poisoning) have resulted when these precautions have not been observed. Frozen or moldy silage must not be used under any circumstances.

In some instances, especially when it is not possible to feed a legume hay, a small quantity of grain is necessary to maintain the horses in thrifty condition. Oats are preferred for use with the coarser roughages, but corn and barley are often used in the winter ration, especially when they are cheaper or when an increase in weight is desired. One or two bran mashes a week or a little linseed meal each day is recommended as an aid in keeping the system in good condition and in preventing impaction resulting from the use of large amounts of coarse roughage improperly supplemented.

Pregnant mares require more attention during the winter than the open mare or gelding. As a lick often causes the loss of a colt, the pregnant mare should not be turned out with other horses, especially if she fights with them. Leguminous feeds high in protein and ash are necessary in developing the fetus. Although the feeding of the legume hay is of more importance than a supplemental grain feed, in most cases such feeds as oats, bran, and oil meal should be supplied, the proportions being largely controlled by the condition of the mare and the stage of development of the fetus.

PREPARING FOR SPRING WORK.

During the fitting period preceding the spring season the horse must be so conditioned that he will be able to convert the vitality and energy which has been stored up during the winter into full power during each work day and even be prepared for an "overload" during the peak of the heavy work. The fitting necessary to condition horses for spring work depends largely on the way they have been wintered. The condition of the horse that has been properly cared for in the open during the winter is more nearly the ideal than that of the horse that has been kept in the stable. While the fitting period varies with the condition of the animal and other factors, the average time usually allotted for it is two to four weeks. A horse that is either very thin or very fat requires a longer fitting period than one in thrifty condition with fair flesh. A young horse also requires a longer time for fitting and training than a mature horse, especially if he has just been broken.

The horseman tones up the digestive system of the horse before and during the fitting period so that it will function efficiently when called on for maximum work. This end is usually accomplished by gradually increasing the ration with the work done. Preparation of horses should begin several weeks before they are actually put to heavy work. While the use of coarse, nonsalable feeds is an economic practice during the winter, the horse should gradually be put on a smaller ration of finer-quality hay early in the spring, and started on a light feed of grain three times daily. When light work has commenced, a 1,400-pound horse should be getting about 14 pounds of grain together with 14 or 15 pounds of fine-quality hay, daily. This gradual change from coarse roughages to good-quality feed will have prepared the digestive tract for the use of from 18 to 19 pounds of grain, with from 16 to 18 pounds of hay, which will be needed by the horse at heavy work, such as disking or plowing.

It should be remembered that changes in both kind and quantity of feed should always be made gradually.

It is also necessary that the work horse be gradually conditioned, or hardened, for heavy work. By increasing the work gradually, the muscles are hardened, and the horse gradually develops strength for the heaviest work. During this period, special attention must be given to the shoulders, a discussion of which will be found on page 15.

GROOMING AND CLIPPING.

Grooming improves the general appearance of a horse, and, what is more important, removes the internal waste of the body which has been exuded through the pores of the skin, and the loose scurf. If this waste matter is not removed by thorough grooming, the pores of the skin will be stopped, normal body activities hindered, and the general health of the animal impaired. This condition is indicated by a harsh skin and dry, rough appearance of the hair. The skin of a well-groomed, healthy animal is pliable and soft, and the hair glossy. Because regular grooming so improves the action of the digestive organs and the utilization of feed, it is often said that a good grooming is as valuable as a feed.

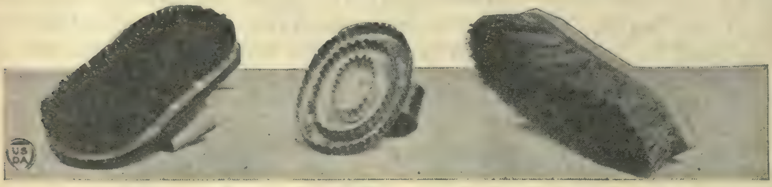

FIG. 6.—Good grooming is essential to the conditioning and health of the animal. Left to right: Bristle or body brush, corrugated comb, and fiber or mud brush.

The amount of grooming necessary varies considerably. Horses that are pastured, or are outdoors, do not require much grooming, as under these conditions there is less perspiration and the waste products are more generally thrown off through the bowels and kidneys. Fast or active work, together with heavy feeding, however, causes free perspiration and throwing off of body waste through the skin, making regular grooming necessary.

Care, regularity, and thoroughness are essential in grooming. It is a good plan to groom the horse at night, for he will rest better, and a good brisk brushing is sufficient the next morning before going to the field. Turning the horse out at night, or allowing him to roll, only partially removes the need of the evening grooming, for only the high spots are touched and very little of the body-waste material is removed.

The common equipment for grooming is the currycomb, dandy brush, and body brush (fig. 6), while the rub rag, mane comb, and footpick are often needed. The currycomb should be used only when the horse is sweaty and dirty. As the skin is very sensitive, a round-corrugated comb is preferred. The dandy or fiber brush should be laid on heavily the first time over the horse. The body brush is then used to remove the loose body-waste substance and scurf, and for the careful cleaning of the fetlocks and pasterns. The feet of farm horses should also be cleaned and the mane and tail brushed and thinned regularly.

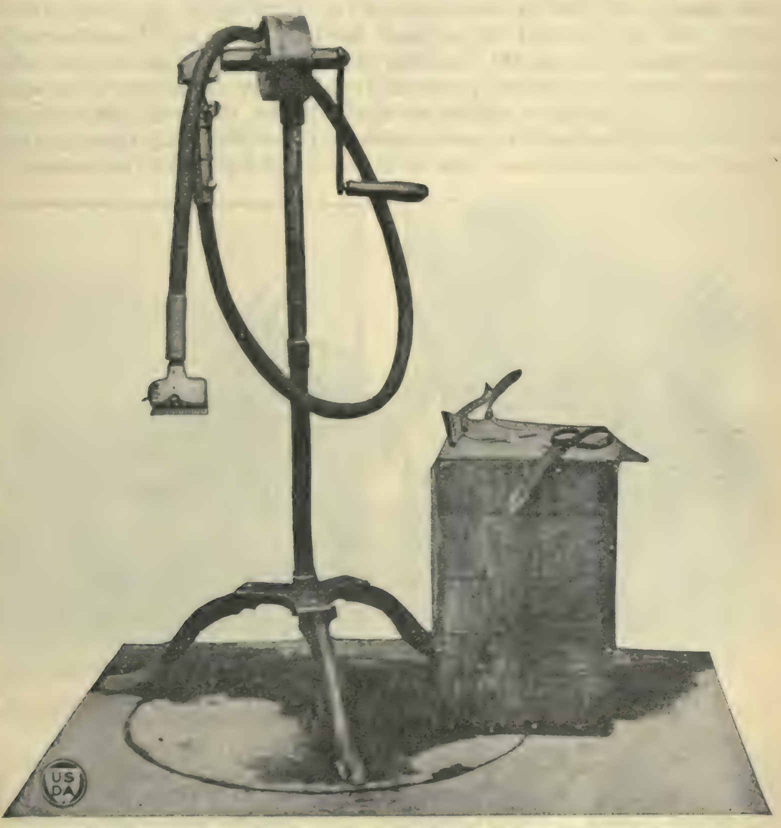

FIG. 7.—Clipping outfit—a hand-power clipping machine, with small hand clipper and shears on box. Clipping saves the horse discomfort in hot weather.

Farm work horses are seldom washed. When this is done, however, all parts should be thoroughly washed with tepid water and mild, alkaline soap and afterwards completely dried. Sawdust or bran is good for drying the legs.

Clipping is advisable, as it saves the horse a great deal of discomfort, and makes grooming easier. (See fig. 7.) The removal of the heavy winter coat makes the horse less likely to sweat, and helps to prevent shoulder soreness. The horse must be blanketed, however, for a time, if clipped early in the spring. The foretop of a farm work horse is often trimmed, but a sore neck is less likely if the mane is not trimmed at the collar seat. When draft horses are being produced for city use, the foretop should not be removed, as it is needed to satisfy the demands of the city trade.

THE HARNESS, FITTING AND CARE.

All parts of the harness should fit the horse comfortably yet snugly. It is of special importance for the collar to fit, so that when it is adjusted the pull will be distributed equally over the shoulders. The best plan is to have a good, heavy, leather collar for each horse, and always use his own collar on him. To fit, there should be barely room for the flat hand to pass between the collar and the windpipe, and for the finger tips to pass at the side of the neck just above the shoulder points. (See figs. 8 and 9.) A short collar chokes the horse when pulling, while a collar which is too long bruises the shoulder points and chafes the neck at the withers. A narrow collar will pinch. A wide collar will bring pressure and irritation on the side of the shoulder. The condition of the horse should be taken into account when a new collar is fitted, due allowance being made for excess hair and surplus flesh, if the fitting is done in the spring.

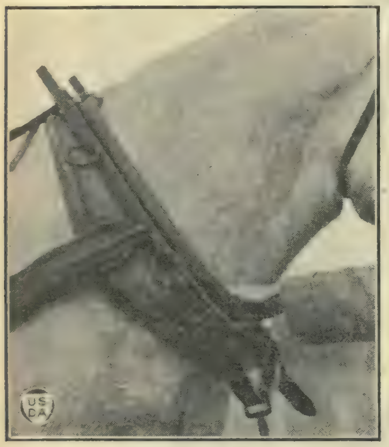

FIG. 8.—Just room for the flat hand between collar and windpipe.

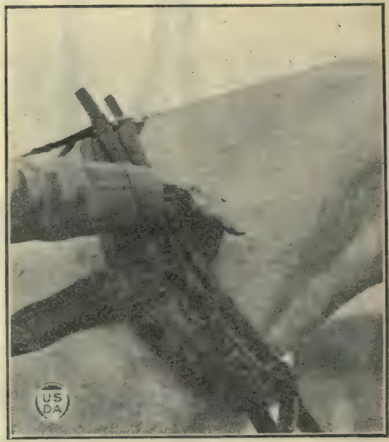

FIG. 9.—Room for the finger tips at the side.

THE FIRST STEP IN ELIMINATING SORE SHOULDERS IS A CORRECTLY FITTING COLLAR.

Sweat pads are a poor means of making a collar fit. They are hot, and easily wrinkled, stick to the shoulder, have a surface that is hard to keep clean, get hard when dry, and cause more sore shoulders than do smooth and solid surfaces. Hames that do not fit offset a good-fitting collar and cause sore shoulders, whereas properly fitted hames should assist in bringing about the right setting for the pull. The hames should fit snugly, and be drawn tightly on the collar, so that the point of draft will be about one-third of the distance above the point of the shoulder.

All other parts of the harness must also be properly adjusted and fitted. In adjusting the bridle, the bit should rest snugly on the bars of the mouth, and the checkrein should be used but mildly. The body parts of the harness should fit snugly, but not so as to retard free full motion, while the adjustment of traces and lines is required for an even pull and perfect control.

The life of the harness is prolonged by the care given it. When the harness is not in use, it should be hung up carefully, in a dry harness room. A little care in removing the collar from the horse, keeping it in shape, and hanging it on a peg or rack by itself, will probably prolong its life very materially. Many collars are broken and ruined by careless handling. Cleaning the face of the collar, and other bearing surfaces of the harness, with a damp cloth, at the time the harness is removed from the horse, keeps these parts smooth and firm, thereby helping to prevent galls and sore shoulders, as well as adding to the life of the leather. While most of the mending must take place at the time of the breakage, it is well to go over all harness carefully during dull seasons, replacing weak parts and restitching ripped places. A harness repair kit (fig. 10) is essential equipment for every farmer. The kit consists of a riveting machine, 4-tube punch, a pair of pliers, awls, an assortment of needles, a ball of good thread with wax, a wood clamp, leather, snaps, buckles, and cleansing and oiling materials. The round knife, edged tools, and creasers make possible the use of side leather and more complete saddlery work.

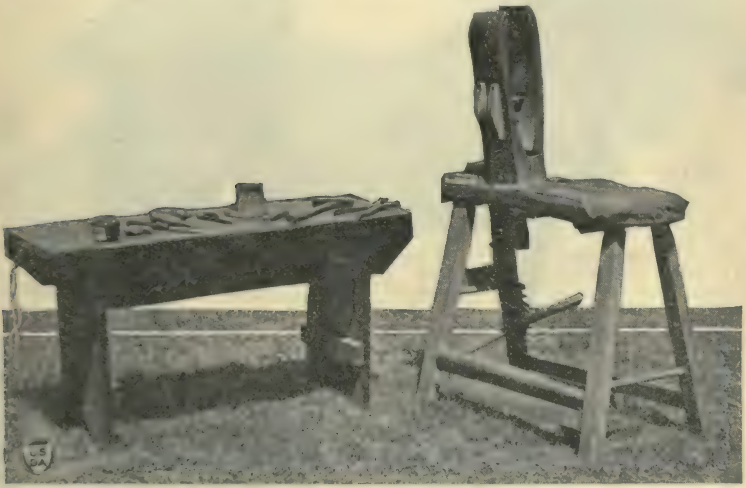

FIG. 10.—Harness-repair kit, consisting of clamp, 4-tube punch, riveting set, pliers, awls, knife, needles, thread, and wax.

A thorough overhauling, cleaning, and oiling of the harness once or twice a year in addition to the daily cleaning of bearing surfaces and careful handling, prolong its life. At least once a year the harness should be taken apart so that all parts may be thoroughly cleaned, oiled, and repaired. To clean, soak the harness about 15 minutes in lukewarm water in which a mild soap has been dissolved. Adding a little soda makes the water a better solvent.

Each strap should be scrubbed carefully and rinsed well. When nearly dry rub edge blacking on all parts where required, clean the metal parts, and make needed repairs. The leather should then be oiled while still damp, using neat's-foot oil, castor oil, or one of the prepared harness oils. A very good mixture for heavy harness is neat's-foot oil, mixed with tallow to make a paste of about the consistency of butter, warmed slightly.[3] All oils should be thoroughly rubbed into the harness, and be allowed to dry slowly, being hung neither in the sun nor close to a fire. When the oil has dried, the straps should be rubbed well with a lather made of white castile soap, or a good harness soap. This will remove surplus grease and take away the greasy appearance. With regular care the leather will be clean and pliable. Frequent sponging will keep the harness like new.

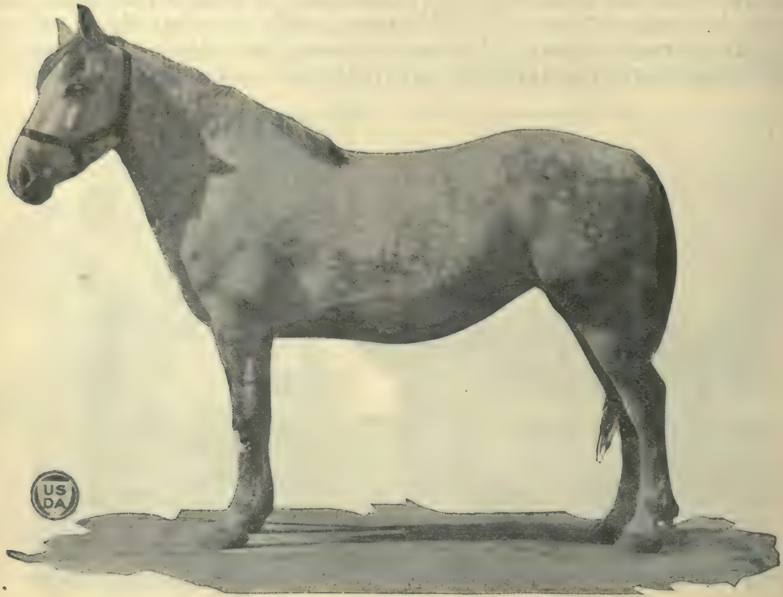

FIG. 11.—Farm mare with properly trimmed feet. Regular care of the feet, so that the horse stands square and plumb, will relieve needless tendon strain and avoid deformity of the feet, unsoundness, and improper action.

PREVENTING SORE SHOULDERS.

Correct fitting of the collar, and adjustment of the harness, is a big step in the elimination of sore shoulders. The shoulders of work animals should be given special attention during the spring fitting season until the muscles harden and winter hair sheds off. Clean the shoulders carefully after the day's work is done, and before harnessing next morning. When the harness is taken off, wash the shoulders with warm water and castile soap, and rinse with cold water to which a small amount of salt has been added. This treatment may be discontinued after two or three weeks, but careful daily grooming and cleaning of the collar are always required. A little time given in special attention to the shoulders in the field during the early spring is time well used. Raise the collar frequently and clean the sweat, dirt, and dead hair from both the shoulder and collar. Lift the collar forward on the neck and leave it there for a few minutes, so that the shoulder surface may cool off. It is especially important that the neck and shoulders be cleaned and given a chance to dry and cool off during the noon hour.

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[3] For further information, see Farmers' Bulletin 1183, "The Care of Leather."

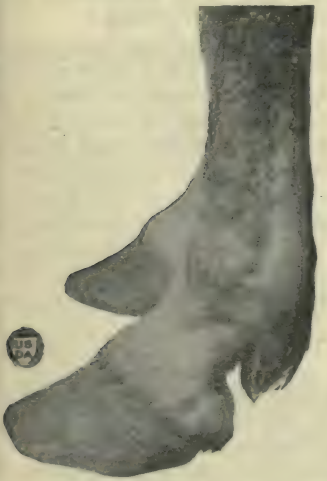

FIG. 12.—Left forefoot of horse in Figure 11, before trimming.

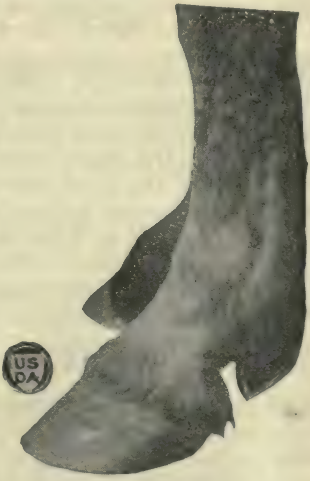

FIG. 13.—Same foot, after trimming. Notice change in angle of pastern.

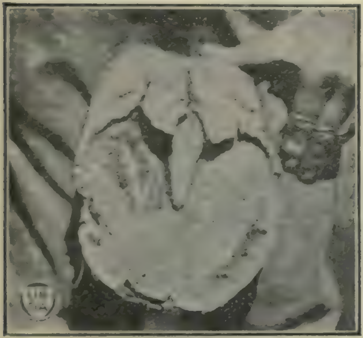

FIG. 14. Bottom of hoof before trimming.

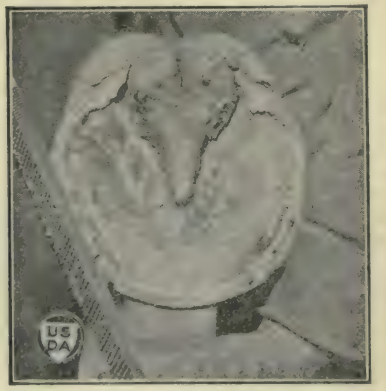

FIG. 15.—Same view, after trimming.

CARE OF THE FEET.

Care of the feet at all times, so the horse stands square and plumb, will relieve needless strain on tendons and prevent deformity of the feet, unsoundness, and improper action. (See figs. 12 to 15.) When the horse is not shod, loose pieces and rough corners of horn should be trimmed off with nippers, and the wall leveled regularly with the rasp.

Horses used on hard roads, and in some cases those running on hard or frozen fields, should be shod. The shoes should be made to fit, and the reshoeing or resetting of the old shoes should be done regularly to prevent injury to feet and legs. Toe calks and heels should be provided during the winter to prevent slipping.

When the feet are cleaned daily, they usually remain healthy and the wall of the hoof tough, whereas lack of exercise and close stabling under foul conditions cause an unhealthy condition of the feet. The hoof occasionally becomes brittle, however, because of lack of moisture. Sometimes the right moisture conditions are obtained by soaking or poulticing the hoof and then dressing it with neat's-foot oil or sweet oil to prevent further drying out. Packing the feet with powdered white rock or blue clay is also a good corrective, and restores a healthy condition. Frequent cleaning of the feet of shod horses tends to prevent inflammation and more serious troubles which commonly result from stones or clods packing in the sole of the foot.

CARE OF THE TEETH.

At least once during the year a competent veterinarian should examine the teeth of all horses. Generally all that will be required is the "floating" or filing off of the long, sharp corners which are due to uneven wearing. This roughness first causes sore tongues or cheeks, followed by a lack of proper mastication together with digestive troubles. Older horses particularly are often greatly benefited by proper attention to the teeth.

HINTS FOR THE HORSEMAN.

Make hitches carefully, in order that the pull will be at the center of draft, and that each horse will pull his share of the load. The strongest horse should usually have as much of the load as suits his power.

Do not work a slow horse and a fast horse together. There will be friction and loss of power, in addition to irritation to both driver and horses.

Give special consideration to the arrangement of horses that are hitched three or four abreast. If a horse worries when worked between other horses, rearrange the team so that this horse works quietly.

At the beginning of the day's work, warm up the horses gradually. The digestive tract will be emptied, the muscles and joints limbered up, the collar will be made pliable and set to the shoulder, and the whole machine will be in better condition for the day's work.

Work the horse at his normal gait in the field. He can not work efficiently above his normal gait for any great length of time, even though he is pulling a light load.

Sweating during hot weather indicates that the cooling system is working. Puffing may be a serious warning, especially if the horse has ceased to sweat, and overheating may result if the horse is pushed at this time. A brief rest, a swallow of water, or a sponging of the mouth will often restore normal action and avoid serious consequences.

An important phase of horse husbandry is to avert common ailments. Every horseman should know how to take necessary precautions in avoiding various troubles, to care for minor ailments, and start immediate-relief measures until the services of a competent veterinarian can be obtained.[4]

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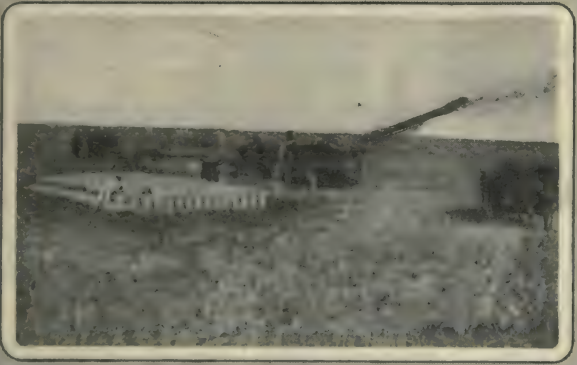
[4] The department has published a book entitled "Diseases of the Horse." This book may be obtained free from a Senator or Representative in the Congress of the United States. Or, it may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., for $1. (Stamps are not accepted.)

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1925

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1420

HANDLING ROUGH RICE TO PRODUCE HIGH GRADES



THE ENTIRE RICE INDUSTRY will profit by the production and marketing of better rough rice. A crop which is of uniformly high quality will result in greater returns to the producers, will facilitate domestic distribution and foreign exportation, and will create a stronger demand for American rice, all of which conditions will cause a firmer and steadier market.

High-quality milled rice can not be produced from low-quality rough rice. Rough rice will not command high prices unless milled rice of high value can be produced from it.

Many of the factors which cause rough rice to bring a low price on the market can be reduced or eliminated. This can be accomplished by the use of better seed, by better cultural methods, by harvesting the crop when it is in the proper stage of maturity, by improved methods of shocking and threshing, by cleaning the threshed rice, and by providing suitable storage facilities for the threshed grain.

Weeds and red rice cause a reduction in yield and lower the value of the threshed rice. The elimination of weed seeds and red rice from seed rice and the eradication of weeds and red rice in the fields will result in a higher monetary return to the producer.

Other grains should not be mixed with rough rice. Such mixtures are a troublesome factor in milling and result in reduced values.

Washington, D. C. Issued June, 1924

HANDLING ROUGH RICE TO PRODUCE HIGH GRADES.

By W. D. Smith, *in charge Rice Investigations, Grain Division, Bureau of Agricultural Economics.*

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THE MARKET PROBLEM.

RICE IS USED almost exclusively for human consumption, and it goes to consumers largely in a form which makes it peculiarly sensitive to defects of quality, even such as affect merely its general appearance. In the process of milling all defects must be removed if the highest competitive price is to be secured. High-grade milled rice can not be efficiently produced from low-grade rough rice.

The United States rice crop of 1923 amounted to 33,256,000 bushels of rough rice, produced chiefly in Louisiana, Texas, Arkansas, and California, though some rice is also produced in South Carolina, Georgia, Florida, and Mississippi. The crop of 1922 was the third largest crop made since 1904, the first year statistics were available, while the 1923 crop was the smallest crop since 1915. About half of the crops of 1919–1921 were exported, and while there have been some imports of rice, these have been increasingly smaller since 1917, when there was a short crop and heavy consumption.

The annual per capita consumption of rice in the United States is about 6.8 pounds, which is materially less than that of any of the other cereal grains produced here. The secondary position of rice in the diet of the people of this country, together with the large surplus for export, tends to create a market condition in which the prices to producers are rather definitely dependent on what can be obtained for the finished product, the demand for which is limited by custom rather than by comparative food value. The price for rough rice also varies with the cost of milling, which is intimately associated with the grades of rough rice. Rough rice can not command a high price unless a high percentage of milled rice of high value can be produced from it.

The effective demand for whole-grain rice has much to do with the prices paid for rough rice. The grower must produce rough rice which will yield a high proportion of sound head milled rice if he is to obtain the best possible price afforded by the market, for the quality and condition of rough rice governs to a marked degree the quality of the milled rice and also the cost of milling through mill yields. The various factors that reduce the value of rough rice for milling purposes are largely within the control of growers.

CLASSES OF ROUGH RICE.

Rough rice is classed according to size and shape of kernels[1] as Long, Short, Round, and Mixed Rough Rice. Each of these classes requires separate treatment in the milling process, as milling efficiency is affected by a mixture of classes of rough rice. In the beginning of the milling process the hulling stones are usually set to take the hulls off the longest kernels first; the shorter and smaller kernels escape being hulled at this time. The shorter kernels are then put through "return stones," which are set closer, so that the hulls of these kernels may be loosened, too. In case there is only a small percentage of long-grain rough rice in a lot of short-grain rice, it is not practicable to set the first stones to take care of the few kernels of long-grain rice in the mixture only, as that would seriously delay the process of milling. In such a case the stones must be set to loosen the hulls on the longest kernels of the short-grain rice, and when this is done most of the long-grain rice is broken in the stones and the percentage of whole-grain rice that can be made from the lot is reduced.

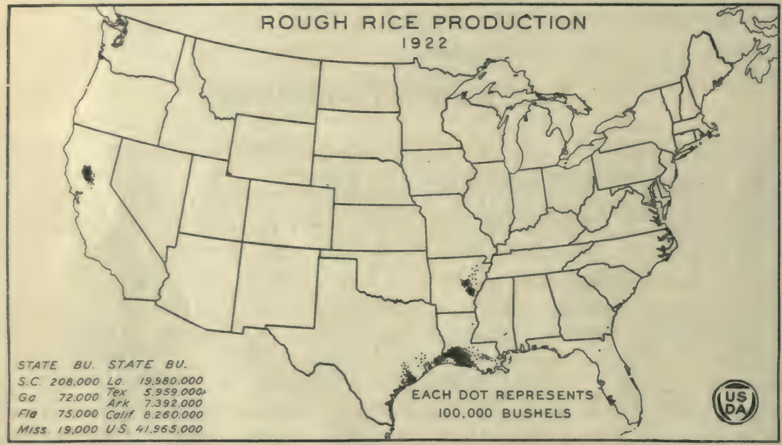

FIG. 1.—Areas of heaviest production of rice in the United States.

Difficulties caused by mixture of classes may be overcome by growing one class only or by keeping the classes separate on the farm.

GRADES FOR ROUGH RICE.

The United States standards divide each class of rough rice into seven grades. The first six grades are numbered and the last is designated as Sample Grade.

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[1] See Department Circular No. 290, United States Grades for Rough Rice, effective August 1, 1923, recommended by the United States Department of Agriculture for the grading and marketing of rough rice.

Rough rice, to meet the highest grade, must contain a large percentage of sound vitreous kernels, must have a low moisture content, and must be practically free from foreign seeds, other grains, red rice, and damaged kernels. Such rice will produce a high milling yield of whole kernels (head rice) of good quality and will therefore bring a high price on the market.

Grade No. 1 for the class of rough rice which includes the short-grain rices, such as those known commercially as Blue Rose, Louisiana Pearl, and Early Prolific, requires that the rice to meet this grade—

(*a*) shall be cool and sweet, and of good color,
(*b*) shall have a test weight per bushel of at least 45 pounds,
(*c*) may contain not more than 14.5 per cent of moisture,
(*d*) may contain a total of not more than 1.5 per cent of damaged kernels, red rice, and foreign material, which total of 1.5 per cent may include no heat-damaged kernels, not more than 1 per cent of kernels damaged other than by heat, not more than 0.5 per cent of red rice, not more than 0.1 per cent of cereal grains, not more than 0.1 per cent of seeds, and not more than 0.2 per cent of foreign material other than cereal grains and seeds,
(*e*) may contain not more than 2 per cent of broken hulled kernels, and
(*f*) may contain not more than 1 per cent of whole kernels of rice of other classes.

The same requirements are specified for grade No. 1 for the class which includes all long-grain rough rices, such as those known commercially as Honduras, Carolina Gold, Carolina White, Fortuna, and Edith, and the class which includes all round-grain rices, such as those known commercially as Japan or Japanese, including Wataribune, Shinriki, Butte, Acadia, Colusa, Ousen, and Calora, except that the test weight per bushel required for No. 1 Long rice is specified as 43 pounds and for No. 1 Round rice the minimum test weight is 46 pounds.

COMMON DEFECTS OF ROUGH RICE.

The common defects appearing in rough rice are: Red rice, weed seeds, other grains, small mud lumps, gravel, stones, other foreign material, thresher-broken kernels, damaged kernels, heat-damaged grains, a high moisture content, and a low test weight per bushel. All these reduce the value of rice containing them, principally because the quality and condition of the rough rice governs to a very large extent the cost of milling the rice, the milling yields, and the quality and condition of the milled rice that can be made from the rough rice.

It is possible to remove some of these defects from rice in milling, but when any one of them is present to a high degree in the rough rice it is very difficult and often impossible to prevent its appearance in the milled rice. The commercial value of milled rice is based largely upon its general appearance. Every reasonable precaution should therefore be taken by the grower to prevent the appearance of defects in the rough rice before it goes to the mill in order to make it possible for the miller to produce high-grade milled rice.

MILLING DIFFICULTIES CAUSED BY DEFECTS.

The daily output of the mill is often greatly retarded because of the common defects in rice. Moreover, most of the foreign material removed from rough rice during its preparation for milling is worthless to the miller and it costs money to remove it. Foreign material, consisting of pieces of straw, sticks, large mud lumps, and the very large and very small weed seeds, can be removed comparatively easily from rough rice during the preparation of the rice for milling, but such defects that are of approximately the same size and shape as the rice kernels are very difficult to separate from the milled rice. Some of the weed seeds have other characteristics that make them particularly difficult to eliminate.

Damaged kernels usually break more easily than sound kernels and a milling loss is caused because of a decrease in the yield of whole kernels and an increase in the yield of broken particles and byproducts. In milled rice the various classes of broken rices generally sell for from 1 to 4 cents a pound less than the whole-grain rices. Damaged kernels in the rough rice usually show in milled rice even when they do not break up in milling.

False kernels, or kernels of rough rice which have little or no substance in the hulls, and very small immature kernels are cleaned out of rough rice at the mill with the foreign material and represent the same kind of loss to the miller as foreign material. Immature kernels which are large enough to stay in the rice during milling are often chalky in texture and are generally broken in the milling operation. In addition, admixtures of immature and false kernels reduce the weight per bushel or "cup weight" of rough rice somewhat, and consequently tend to lower the grade.

Thresher-broken kernels, or broken-hulled kernels, reduce the milling value of rice for the obvious reason that as the percentage of broken kernels in rough rice is increased the milling yield of whole-grain rice is decreased.

Excessive moisture in rough rice causes the kernels to be softer and more susceptible to breakage in milling. Damp rough rice often causes some of the milling machinery to clog with damp bran or polish. A high moisture content in rough rice results in damp milled rice and there is danger of spoiling in storage.

Red rice is a very troublesome factor in milling and causes a large financial loss to the rice industry yearly. The red rice paddy kernel is usually smaller in size than the average paddy kernel of the white rices grown in the United States, which makes it difficult to remove the hulls from the red rice in milling, and makes it practically impossible to scour off all of the red bran from the red rice kernels in the mixture. Consequently, a large percentage of the paddy kernels (unhulled kernels) found in milled rice consists of kernels of red rice, and in practically all rice milled from lots which contain red rice there are kernels of red rice on which there are still some streaks of red bran. These red streaks detract from the appearance of the lot as a whole, and as a result reduce the market value of the rice.

When there is a large percentage of red rice in a milling lot the finished rice usually contains not only a large number of red-streaked kernels, but often the color of the finished lot as a whole is affected, because the red bran, coming in contact with the kernels of white rice during the milling operation, imparts to them a rosy or red appearance. As a rule, the kernels of red rice break more easily in milling than those of white rice. For this reason, rough rice that contains red rice is usually milled close, in an effort to remove as much of the red bran as possible from the red rice kernels. The milling yield of whole-grain rice is generally reduced and this reduction is in proportion to the red rice contained in the lot.

HANDLING TO AVOID COMMON DEFECTS.

It is poor economy to spend time and money in producing a crop of rice and then lose part of the quality and profit through poor handling. Defects in rough rice can be reduced considerably or eliminated entirely by careful attention to details throughout the process of production—by the use of better seed, by better cultural methods, by harvesting the crop at the proper stage of maturity, by improved methods of shocking and threshing, by cleaning the threshed rice, and by providing suitable storage facilities for the threshed grain.

GETTING RID OF WEED SEEDS, RED RICE, AND OTHER CEREAL SEEDS.

Presence of red rice and weed seeds in threshed lots is often the direct result of planting such seeds with the seed rice. Many kinds of weed seeds are found in rough rice, but less than 25 occur commonly. The principal one is barnyard grass, which is prevalent in California. The light weight of this seed and its appendage or "tail" cause the difficulty in separating it from the rice. Representative kernels of 24 kinds of foreign seeds commonly found in rough rice are illustrated in Figure 2. The 20 kinds of foreign seeds and grains most commonly found in rough rice, named in the order of their frequency, are: Barnyard grass, tall indigo, curly indigo, alligator head, plantain, oil seed, turtle back, low senna, Mexican weed, king-head, spearhead, buck chess, large button weed, goat's beard, sensitive pea, morning glory, coffee weed, green foxtail, wheat, and barley. As the common names for these weeds vary in different localities, their botanical names are given in Table 1.

TABLE 1.—*Common and botanical name of weed seeds found in rough rice.*

Common name.	Botanical name.	Common name.	Botanical name.
Barnyard grass	Echinochloa crus-galli.	Spearhead	Rynchospora corniculata.
Tall indigo	Sesbania macrocarpa.	Buck chess	Lolium temulentum.
Curly indigo	Aeschynomene virginica	Large button weed	Diodia virginiana.
Alligator head	Diodia teres.	Goat's beard	Molochia corchorifolia.
Plantain	Commelina sp.	Sensitive pea	Cassia nictitans.
Oil seed	Caperonia palustris.	Morning glory	Convolvulaceae.
Turtle back	Croton sp.	Coffee weed	Daubentonia longifolia.
Low senna	Cassia tora.	Green foxtail	Chaetochloa viridis.
Mexican weed	Scleria reticularis.	Wheat	Triticum aestivam.
King-head	Ambrosia bidentata.	Barley	Hordeum vulgare.

BETTER SEED RICE NEEDED.

It is of primary importance that the rice used for seed be free of foreign seeds and red rice and that it show good germinating power. Yet, only 4 lots of the seed rice being planted on 29 farms examined by investigators contained neither weed seeds nor red rice, while all the others showed the presence of either one or both kinds of seed. Too often it is thought that a few kernels of red rice or a few weed seeds in a small lot of seed rice is not particularly harmful, but

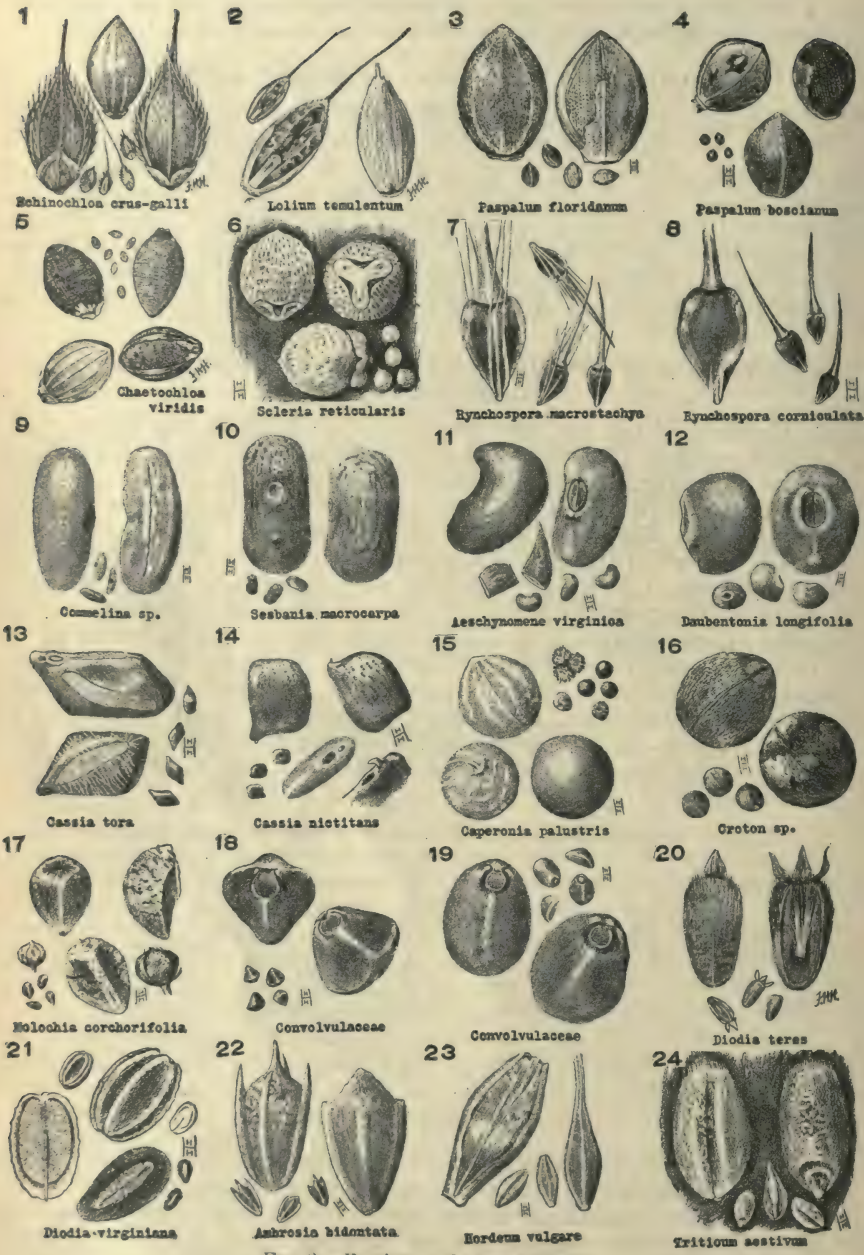

FIG. 2.—Foreign seeds found in rice.

although the amount of these noxious weeds may be seemingly small the number of them planted on an acre is alarmingly large. The combined number of weed seeds and red rice being planted per acre on one farm totaled over 16,000.

During recent planting seasons samples of seed rice were obtained from different localities throughout the rice-producing areas of the South, and were examined for red rice and weed seeds. The results are shown in Table 2. Only about one-fourth of the samples obtained were free of red rice. An average of 32 grains of red rice per pound was found in these samples. On the basis of sowing 80 pounds of seed rice per acre, this would mean that an average of 2,560 seeds of red rice were planted on each acre of ground along with the white rice. The seed rice being planted on 2 of the farms showed that approximately 11,000 seeds of red rice were being planted per acre; on 3 farms, between 5,000 and 10,000 red rice seeds; on 4 farms, between 2,000 and 5,000 seeds of red rice; and on the remainder of the farms the samples indicated that red rice seeds varying in number from 0 to 2,000 were being planted per acre.

Of the samples obtained, approximately 45 per cent contained no weed seeds. The average number of weed seeds per pound for all the samples was 34, or 2,720 planted per acre. The weed seeds commonly known as tall indigo, curly indigo, plantain, yellow foxtail, and king head predominated in these samples.

Considering both red rice and weed seeds as foreign seeds, one sample showed that 16,880 foreign seeds were planted per acre; 3 samples indicated that from 10,000 and 15,000 foreign seeds were being sown; 4 samples indicated that between 5,000 and 10,000 foreign seeds were being planted; 8 of them indicated the planting of between 2,000 and 5,000 foreign seeds; and the remainder of the samples indicated that foreign seeds varying in number from 1 to 2,000 were being planted per acre.

Table 2.—*Weeds and red rice planted per acre with seed rice, based on 80 pounds of seed rice per acre.*

Seed sample number.	Weed seeds.	Red rice seeds.	Total weed and red rice seeds.	Seed sample number.	Weed seeds.	Red rice seeds.	Total weed and red rice seeds.
	Number.	*Number.*	*Number.*		*Number.*	*Number.*	*Number.*
1	2,480	1,440	3,920	16	1,120	2,480	3,600
2	0	10,800	10,800	17	0	720	720
3	9,360	0	9,360	18	400	9,680	10,080
4	3,920	0	3,920	19	10,080	6,800	16,880
5	1,040	1,040	2,080	20	0	400	400
6	400	1,440	1,840	21	320	720	1,040
7	0	3,920	3,920	22	0	2,080	2,080
8	0	0	0	23	0	960	960
9	5,040	1,040	6,080	24	2,560	0	2,560
10	0	320	320	25	400	0	400
11	0	1,760	1,760	26	720	1,760	2,480
12	0	0	0	27	1,760	10,080	11,840
13	0	1,440	1,440	28	0	0	0
14	320	2,160	2,480	29	1,120	5,760	6,880
15	0	0	0				

GOOD CULTURAL METHODS ESSENTIAL.

Improved cultural methods result in more rice of a higher grade. Good cultural methods require that the fields and levees be kept free of weeds and red rice at all times. It is not enough that the surface of the land be cleared of these pests just prior to planting, for many of these noxious weed seeds and red rice remain in the soil and the fields are soon as badly infested as ever. Unceasing efforts are required for thorough eradication. The custom of building high and narrow levees in the fields is rapidly falling into disfavor with progressive farmers. Such levees are undesirable because they are too high and narrow to be planted to rice and they serve as an excellent place for noxious weeds to thrive. (Fig. 3.) Low, broad levees should be used and should be planted to rice like the remainder of the field. Weeds and red rice which grow in the fence corners, around the edge of the fields, and along irrigation canals should be cut several times each year to prevent the seed from maturing.

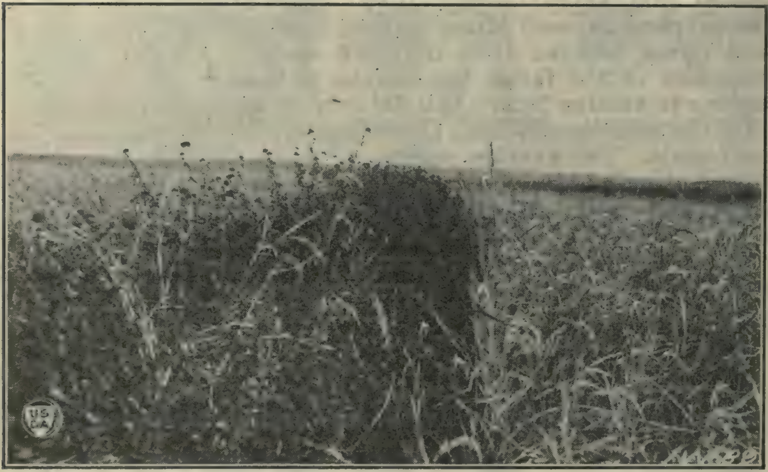

Fig. 3.—A heavy growth of weeds on a levee in a rice field. This condition may be prevented by building low, broad levees and seeding them to rice. Seeds from these weeds will scatter over the field and many will appear in the threshed rice. Value of rice is lowered materially by the presence of weed seeds.

Red rice plants are sometimes found growing in the rice fields even when the seed rice may have been free of red rice. This is especially true where the same land is planted to rice year after year. It is usually because the red rice that grew in a previous crop of rice scattered its seed before or during harvest and came up as volunteer plants. The red rice plants (fig. 4) are easily distinguished after they have headed and, when they are not too numerous in the field, it is profitable to remove them by hand before the seeds mature. Cooperative experiments conducted at the Rice Experiment Station, Crowley, La., show that in badly infested fields red rice may be controlled and eventually eradicated by growing the rice crop in rotation with the Biloxi soy bean.

When a rotation of crops is practiced, care should be taken to prevent the admixture of other grains with rice. In the rice-producing areas of the United States where wheat and barley are raised, mixtures of these grains sometimes occur in the rice fields. It is not likely that barley and wheat seed, if planted with rice, will germinate and grow in those parts of the fields that are covered with water, but both of these cereals will grow and mature on the levees and on other high spots. Fields that have been seeded to barley or wheat and, because of a poor stand of grain, are later planted with rice, are especially likely to produce a mixed crop along the levees unless care is taken to eradicate thoroughly all plants of the cereal first planted.

It is common practice in some sections where rice is cut by hand to cut the rice only, and to allow the weeds to remain standing in the field, where they mature and scatter their seeds on the ground, and therefore the following crop contains more weeds than the previous one. This is an economic waste that costs rice producers heavily each year. Cutting and burning such weeds immediately after the rice is harvested, to destroy the seeds and prevent them from infesting the following crop, will remedy this condition. Figure 5 shows a rice field heavily infested with weeds.

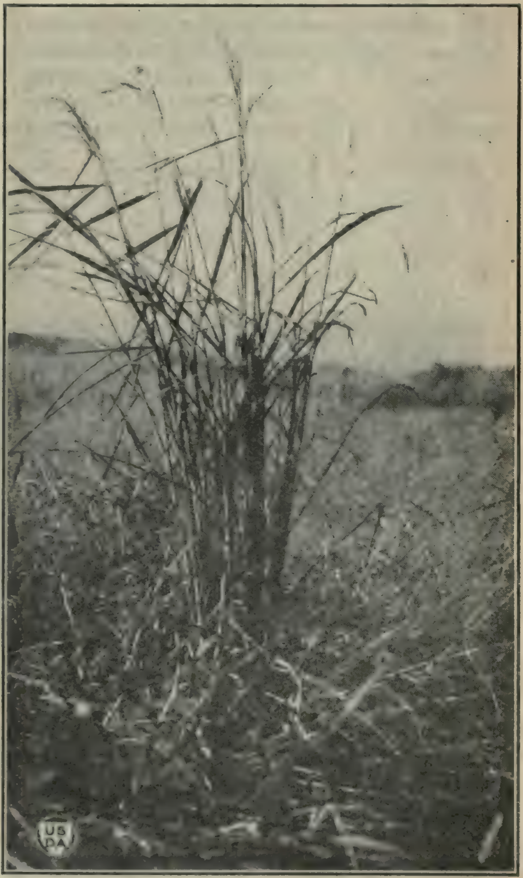

FIG. 4.—A red rice plant growing in a low spot of a field lying fallow. Note the shape of the panicles. The seed from this plant will shatter and cause the land to be infested with red rice the following season.

MECHANICAL MIXING OF KINDS SHOULD BE AVOIDED.

Care must be taken to see that all sacks for rough rice at threshing time are free of other seeds. New sacks are nearly always clean, but if old sacks are used they should be thoroughly recleaned. Any seed other than rice that may be contained in a sack is readily detected with a "trier" when the rice is sampled, and the presence of even a small percentage of other seeds in a sample of rice tends to lower the value of the lot. It may be that all of the "other cereal grains" found in the sample are only the few kernels that stuck to the inside of the sacks, but unless all sacks are opened and the contents carefully examined there is no way of knowing whether the sample drawn with a trier is truly representative of the lot or not, so that such rice is likely to sell at a discount. This uncertainty may be eliminated by the use of absolutely clean sacks.

When more than one kind of grain is stored in a warehouse, care should be taken to avoid mixtures. In some sections rice is often stored alongside other grains, and mixtures which are later discovered are the result of careless handling in storage. Sacks of rice sometimes burst in the warehouse and when the rice is swept up and put into new sacks kernels of other grains lying on the floor may be put in the sacks with the rice.

Occasionally sacks of barley or wheat are loaded into a car with a shipment of rice and these grains are at times inadvertently "cut in" with the rice at the mill and the mixture lowers the value of the rice materially. Cars used for the shipment of rough rice, whether in sacks or in bulk, should be thoroughly cleaned before loading to remove all grain left on the floor and around the sides. If bulk rice is loaded into a car in this condition a mixture of rice and these other grains occurs immediately.

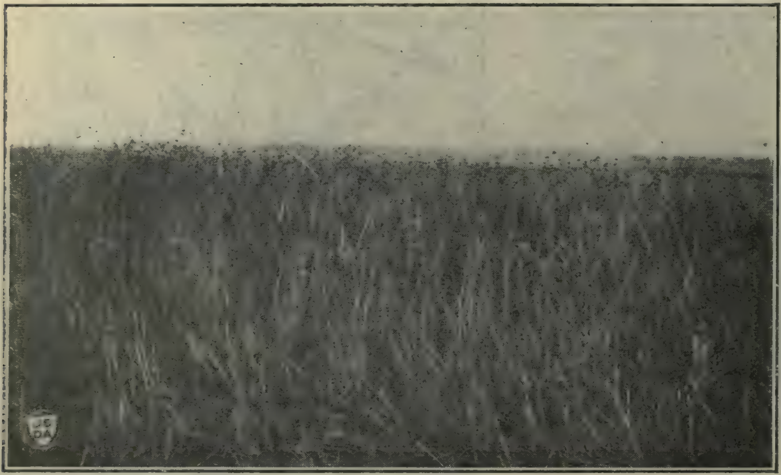

FIG. 5.—A partially cut field of rice badly infested with weeds. The threshed rice from this field will be very seedy and will be of much less value than if it were free of weed seeds.

PREVENTION OF DAMAGED KERNELS, MOISTURE, AND FOREIGN MATERIALS.

The rice crop may be well grown, true to class, and free from weed seeds, red rice, or other cereal seeds, yet suffer serious loss of grade at harvest time and later. The stage of maturity at harvest has considerable influence on the quality of the threshed rice. When harvesting is done before the crop reaches the proper stage of maturity there are many shriveled, chalky, lightweight kernels, and when harvesting is delayed until the crop is overripe the kernels become brittle. The result in either of these cases is that many more of the kernels are broken during the threshing and milling operations than if rice is harvested at the right time, when the kernels are sound, plump, and well matured. The best time to harvest is usually when the kernels in the upper portion of the majority of the heads are just approaching the hard stage. Cutting should then proceed rapidly, otherwise the last rice cut may be overripe.

The method of cutting and shocking affects the moisture content, field curing, efficiency of threshing, and presence of mud lumps. Two methods of harvesting rice are common in the United States—harvesting by hand and harvesting with a grain binder. (Fig. 6.) Both methods are conducive to the production of high-grade rice, provided the crop is in the right condition when harvesting is done and proper care is used in the performance of the work.

When harvesting is done by hand, the rice is cut with a "reap" hook and is then spread in swaths on the stubble and later bound into sheaves by hand. By this method, harvesting may be done without bad effects while the rice is still wet with dew, provided it is allowed to lie on the stubble until it is dry, before it is bound into sheaves.

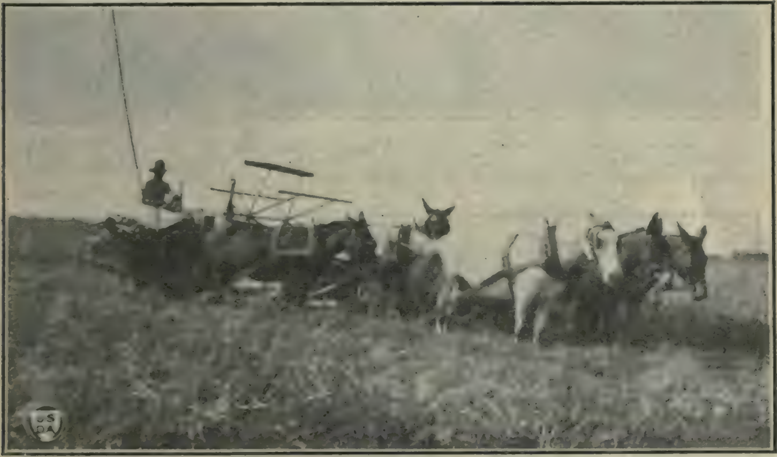

FIG. 6.—A binder at work in a rice field. Rice cut by this method should be put into comparative small shocks. The straw and kernels must lose a large percentage of moisture before the grain will be cured and the loss of moisture can not occur quickly unless the air is allowed to circulate through the shock.

When harvesting is done with a binder, the grain should be free of dew before it is cut. Rice straw at harvest time normally contains a high percentage of moisture, and any additional moisture that may come from the dew and which can not escape readily when the grain is bound into bundles retards and sometimes prevents the natural curing of the grain in the shock. Green weeds contain excessive moisture, and if present in any considerable number prevent, to some extent, the natural drying in the shock. If damp rice bundles are shocked, the rice grains sometimes become moldy and heat damaged.

Whether harvesting may be done more economically by hand or with binders depends chiefly upon the labor situation, weather conditions, and the nature of the soil. When the ground is too soft from recent irrigation or rains for the binder to operate properly, and plenty of cheap labor is available, hand harvesting is probably preferable. The use of binders, however, saves time and labor and reduces the chances of damage to the crop by storms or by becoming overripe before harvesting is finished, because much less time is usually required.

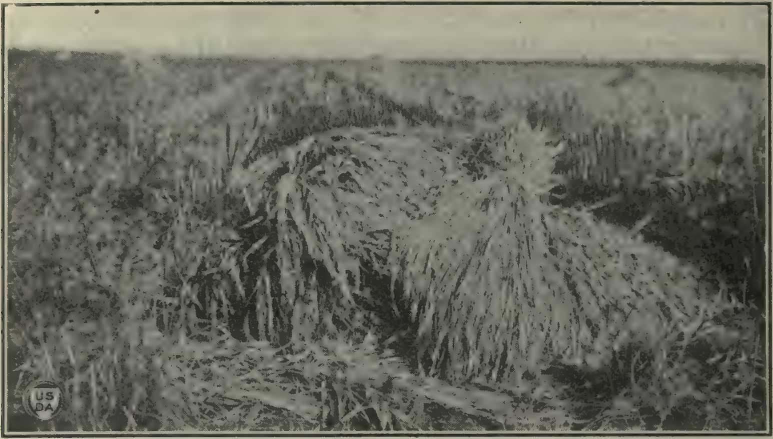

FIG. 7.—This shock was poorly made and has twisted and fallen down. Practically all of the kernels are exposed. In rainy weather rice in shocks of this kind becomes wet and stained and is often badly smeared with mud.

FIG. 8.—Hand-cut rice curing on the stubble. Care should be taken to see that rice is all up on the stubble, as it may absorb moisture if allowed to remain in contact with damp or wet ground.

Carelessness and improper shocking is unquestionably the cause of much damaged rice. (Fig. 7.) When the crop is harvested with binders it is advisable to shock the bundles immediately, for they do not dry out readily on the ground, as they absorb moisture from the soil. When harvesting is done by hand, the grain that is cut in the morning should be left on the stubble at least until the dew dries. (Fig. 8.) After it is bound into bundles immediate shocking is recommended.

Shocks always should be located on the highest ground possible, because the high points are the first to dry after irrigations and they are the least likely to collect standing water from heavy rains. In many instances it is practical to dump the bundles from the binder near the levees, and where there are low, broad levees a large number of the shocks may be set upon this high ground. If rice is shocked in low places, water from heavy rains may get up into the bundles and cause the heads to become damaged or it may saturate the straw so much that threshing is very difficult. Rice bundles standing on wet ground also pick up mud, and threshed rice containing mud lumps sells at a discount.

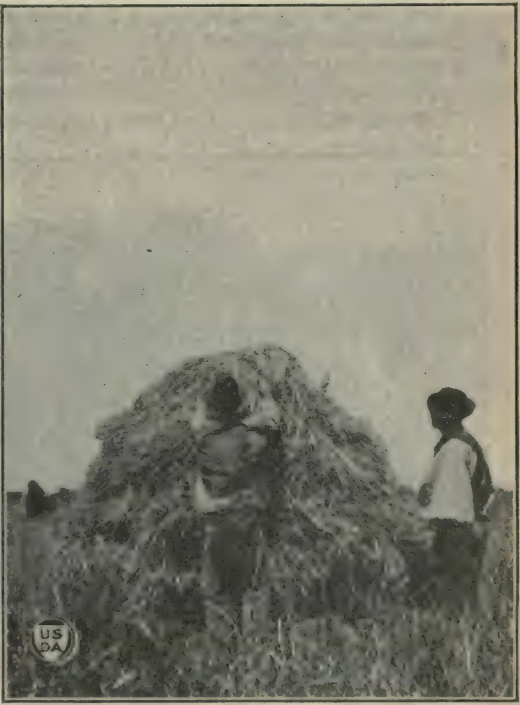

FIG. 9.—A well-made shock of hand-cut rice. The shock is made very compact. Well-cured rice may be shocked in this way without great danger, but damp rice requires more aeration and should be put into smaller shocks.

Shocks that are well built and capped shed water, and the heads of such shocks are protected from the direct rays of the sun. Rice left exposed to the direct rays of the sun for a long time usually becomes brittle. This is detrimental to its milling qualities and causes it to sell for a lower price.

Different methods of shocking are employed for rice harvested by hand than for that harvested with binders. Rice cut by hand and allowed to lie on the stubble until most of the excess moisture has escaped from the straw and grain before binding can be put into slightly larger shocks than rice cut with binders (fig. 9), but such shocks should not be made larger than necessary, for good aeration at all times is beneficial to the grain.

When the rice is harvested with binders it is dangerous to put the bundles into large compact shocks, for it contains practically the same moisture content as when it was cut and a large percentage of this moisture must escape before the grain will be in a suitable condition for threshing and milling. Small-sized shocks facilitate this process. Rice improperly or insufficiently cured before threshing is usually soft and breaks very easily, which makes it of poor milling quality.

The following method of building shocks for machine-harvested rice usually gives satisfaction: Two bundles are set firmly on the ground with the butts about 1 foot apart and the heads pressed firmly together. Two more bundles are then set in the same manner in a position at right angles to the first pair, bringing the heads of all four bundles together. One bundle is then placed in each of the four spaces between the first two pairs of bundles, which makes, in all, eight bundles standing on the ground. Four bundles are used in capping the shock. The butts of all cap sheaves are spread and the first one is so placed that the heads lie on the top of the shock and the butt end hangs well over the east side of the shock. The next bundle is placed so that the butt end hangs over the north side of the shock, the next bundle so that the butt end hangs over the west side of the shock, and the last bundle is so placed that it covers the heads of the other cap sheaves and its butt end hangs over the south side of the shock. (Fig. 10.) The entire shock should be solidly built and the caps firmly placed so that they will not be blown off by the wind. This form of shock, if properly made, sheds water during rainy weather, protects the grain from the direct rays of the sun, and permits thorough aeration.

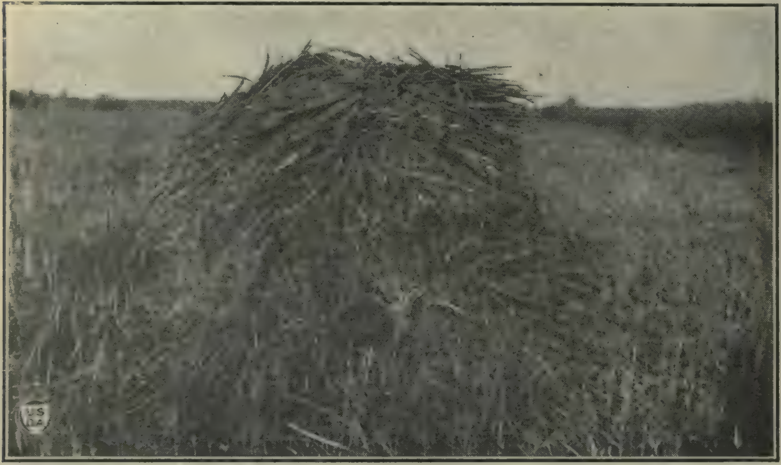

FIG. 10.—A well-made shock of binder-cut rice. The bundles are set up firmly and in such a manner as to allow a circulation of air through the shock. The cap bundles are so placed that very little of the grain is exposed. The heads of the top sheaf hang over the north side of the shock.

The length of time that rice may be safely allowed to stay in the shock before threshing depends largely upon circumstances, but in most cases it is profitable to allow this curing to proceed for at least 10 days or two weeks. If the rice is properly shocked it cures well, threshing is made easy, and the grain when threshed is in good condition for storing and brings a good price when sold on the market. On the other hand, if threshing is done too soon the straw is tough, the seed does not thresh off the straw easily and is likely to be soft and not in suitable condition for storage or milling. Prematurely threshed rice contains an excess of moisture and therefore is subject to spoilage in storage.

If wet bundles are hauled they should not be threshed as soon as brought in, for if they are put into the separator immediately some of the rice is usually lost because the straw is tough and does not thresh well, and much of the wet straw breaks up and goes into the threshed grain. These small pieces of wet straw almost invariably cause some damage to threshed rice in storage. Kernels in a damp or wet spot in stored threshed rice are likely to begin to germinate and cause the rice to become musty or to heat. If the percentage of moisture in such wet spots is comparatively low the damage is usually confined to a small number of "pockets," but if there are a great many such spots and each spot has a relatively high moisture content entire lots of rice are likely to spoil. Such out-of-condition rice receives the lowest grade and price when sold on the market.

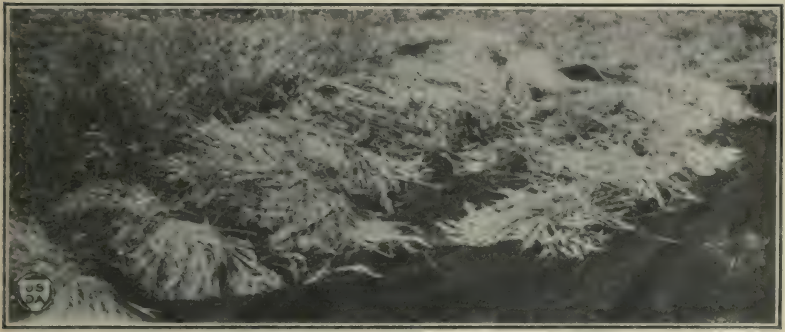

FIG. 11.—Damp and wet bundles of rice being dried on a tarpaulin at the separator before threshing. It is difficult to thresh rice when the straw is wet, and damp rice when put into sacks or into a bin in bulk is liable to spoil in storage.

If bundles are wet but not muddy, it is a good plan to spread them out on a tarpaulin at the threshing separator until dry. (Fig. 11.) They may then be threshed without fear of lowering the market value or endangering the keeping qualities of the threshed rice. But if any of the bundles have mud, in either a wet or dry state, clinging to the butts, all of the muddy part of the straw should be cut off before the bundles are threshed. In case some of the bundles have mud on both the heads and butts it is best to thresh them separately and store the grain separately. By doing this a price-lowering factor is eliminated from the bulk of the crop and the greater part of the grain is made safer for storage purposes. All work of conditioning bundles before threshing should be done on high ground and preferably at the separator.

THRESHING THE GRAIN.

A great deal of rice is lost every season and the quality of much of that saved is materially lowered by improper and careless handling of the threshing separator. The separator should be put in good repair before the threshing season begins and should be kept in good running order throughout the season. Efficient threshing can not be performed with a machine that is not working properly. An even feed of rice into the machine should be maintained whenever the separator is running. If too heavy feeding is done it is not possible to clean the rice thoroughly and some of the rice is likely to be carried over with the straw into the straw stack. If the feed is too light it often results in the presence of a great many cracked kernels in the threshed grain and a reduced market value of the rice. Feeding a separator spasmodically, heavy at times and light at other times, brings a combination of undesirable results.

As it is essential that as much as possible of the foreign material in rice be removed in threshing, it is advisable to inspect the rice from time to time to see how it is running, with reference to cleaning and breakage of kernels, and to catch some of the straw from the stacker at intervals to determine if any rice is being lost in the straw pile.

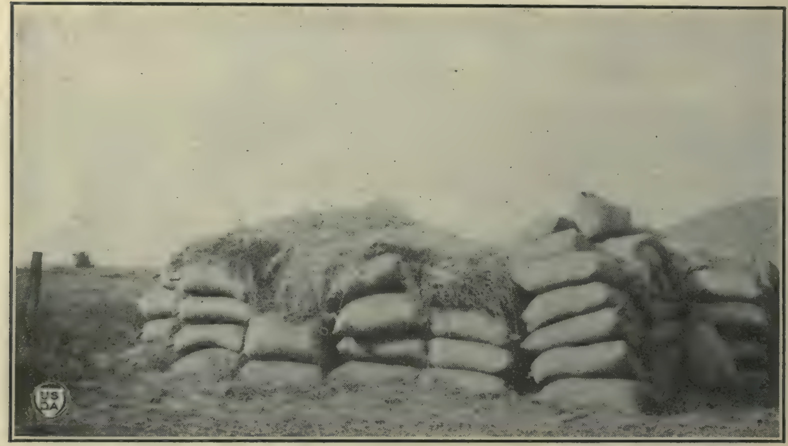

FIG. 12.—Sacks of rice left in the field with practically no protection from the weather. When it is necessary to leave rice in the field temporarily it should be stacked up off the ground and covered with tarpaulins or some other waterproof material.

CLEANING ROUGH RICE.

Rough rice should be thoroughly cleaned for either storing or marketing. Running rough rice through a cleaning machine has several advantages in addition to the benefits derived from the removal of the foreign material. When the rice contains a high percentage of moisture, the aerating it receives in cleaning usually reduces the moisture content and lessens the chances that the rice will heat or become musty. If the kernels have begun to heat or have become musty the cleaning machine can be used to advantage in putting the rice into good condition. Recleaning is also a helpful means of retarding the destruction of the kernels by weevils, as many of the weevils are blown out of the rice by the air blast and others pass through the sieves. If weevil-cut kernels are present, most of the worst ones are removed in the cleaning operation.

Seed rice should always be thoroughly recleaned before planting. A better stand of rice is obtained if the seed rice is free of weed seeds and, what is still more important, the resulting crop will have fewer foreign seeds when it is threshed.

The principal features of an efficient rice-cleaning machine are large-mesh screens for removing the large forms of foreign material, a fan for blowing out the light-weight seeds, straw, dust, and other light matter, and small-mesh sieves for the removal of the broken grains and small weed seeds.

FARM STORAGE.

It is poor economy to take good care of the crop to the stage where the threshed rice is ready for storage and then to allow its quality to become lowered by neglecting to provide suitable storage. The handling of the rice at this time may be the factor that determines whether there will be a profit or loss on the crop.

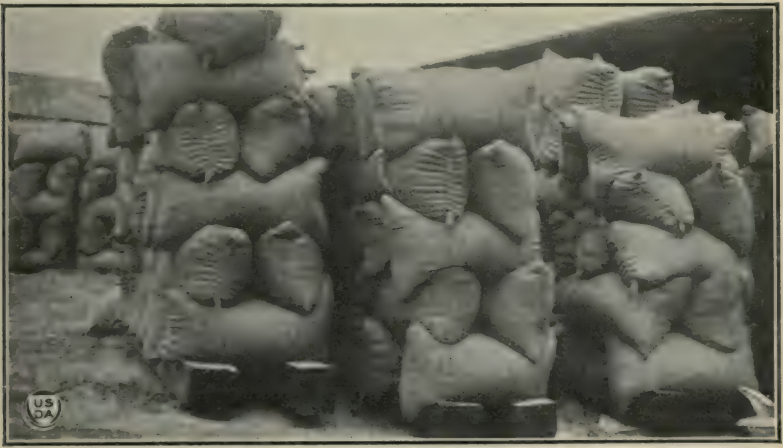

FIG. 13.—Damp rice stacked in the open during favorable weather to prevent spoilage. This method of stacking permits a good circulation of air, which is very beneficial to damp rice. Poles may be used instead of timbers. During damp or rainy weather the sacks should be covered with a good rainproof tarpaulin.

There are two methods of storing rough rice—bag storage and bulk storage—and apparently either method gives satisfaction under normal conditions if care is used. Most of the crop is handled in bags. Regardless of the way in which the rice is to be handled, it is essential for best results that good storage space be provided and ready for use before the crop is threshed.

Bags of rice are often piled in the open near the threshing separator and left there, insufficiently protected from unfavorable weather, for an indefinite length of time. (Fig. 12.) This is a costly practice. When, for some unavoidable reason, it is absolutely necessary to store the sacks in the open, the risk will be much less if poles are first laid parallel to each other on the ground and then another lot of rails laid crosswise on top of these, so that the bottom bags will be raised several inches from the ground. (Fig. 13.) The finished pile of bags should be protected from the sun and weather with a covering that will shed water.

It is always much safer to store the sacks of rice in a shed or warehouse that has a good roof, a dry floor, and is well ventilated. (Fig. 14.) Ventilation of the walls of the storehouses should be so arranged that rain can not be blown in during stormy weather. The manner in which sacks of rough rice should be piled to prevent spoilage in storage is governed by the condition of the grain. It is not likely that well-cured rice, free from foreign material, will go out of condition if it is stored compactly, but great care must be used with rice which contains either a high moisture content or damp foreign material. Such rice is much more likely to become musty or hot and should be stored in a way that will permit thorough aeration.

It is a good plan to stack sacks of damp rice on poles or boards to keep the bottom bags off the floor and to leave open spaces between the tiers of sacks for air circulation. If rice is exceedingly damp, the sacks either should be stood on end separately or the rice can be taken out of the sacks and spread in a thin layer on a dry floor and turned occasionally by hand shoveling. Proper care of damp or wet rice sometimes turns what would otherwise be a loss into a profit. Good ventilation of rice in storage prevents losses from spoilage and aids the escape of excess moisture from the rice, thus hardening the kernels to some extent and increasing its milling value.

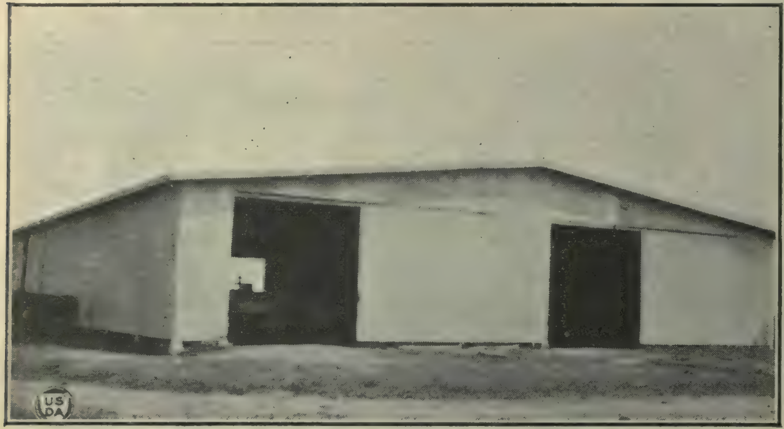

FIG. 14.—This shed was erected on a farm to provide storage space for sacked rice at threshing time and for the protection of the farm implements when no rice is on hand. Sacked rice should always be stored in a dry, well-ventilated place.

BULK STORAGE.

Granaries, bins, and elevators used for bulk storage should be built so that the rice will be protected from the weather and still be well ventilated. Ventilators that permit circulation of air through the grain are of simple construction and lower the risk of grain heating. Such ventilators may consist merely of openings cut in the bottoms of the bins and covered with strong fine-mesh wire to prevent the leakage of rice. For this type of ventilator, it is advisable first to cover the openings with strong wire of any size mesh to support the weight of the grain and then to cover this wire with a fine-mesh screen which will not permit the kernels to pass through. The number and size of the openings in the floors depend to some extent upon the size of the bins and the construction of the floors. It is advisable to have as many openings as possible and to have them as large as possible without weakening the floor. It is best, as a rule, not to have any opening closer than 3 feet to the edge of the building if the space under the bin is not inclosed, as dampness may enter with the air during wet weather. Then the results are harmful instead of beneficial. Whenever possible the space

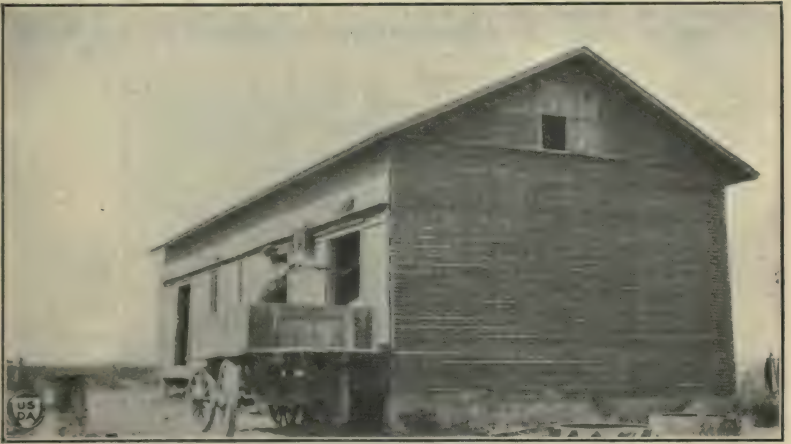

FIG. 15.— A wooden granary used for bulk storage of rice on the farm. Each of the four doors opens into a separate bin, which provides for the storage of four different kinds or grades of rice. The bin partitions are only as high as the eaves and in each end of the granary there are windows in the gable which allow ventilation.

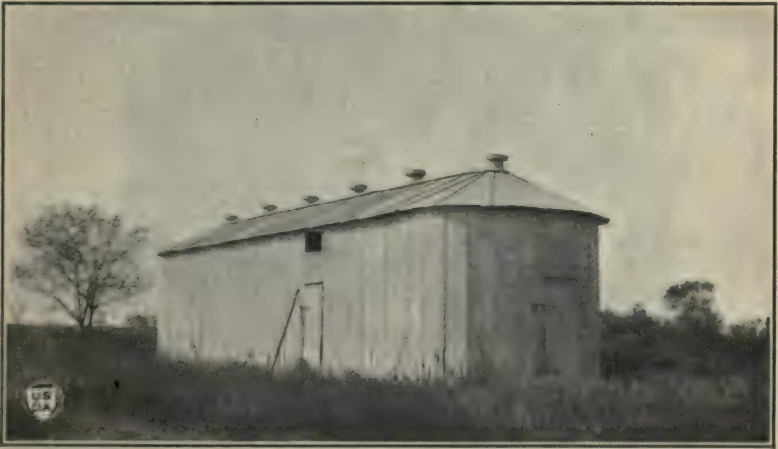

FIG. 16.—One type of steel granary for the storage of bulk rough rice. Rice to be stored in this manner should be well cured before storing.

under the bin should be inclosed in such a way as to prevent the entrance of outside air in rainy weather.

To insure circulation of air through the rice, openings should be provided at the tops of the bins. In buildings that have gable roofs, and in which the bin partitions are not higher than the eaves, it is best to make the top openings in the ends of the building.

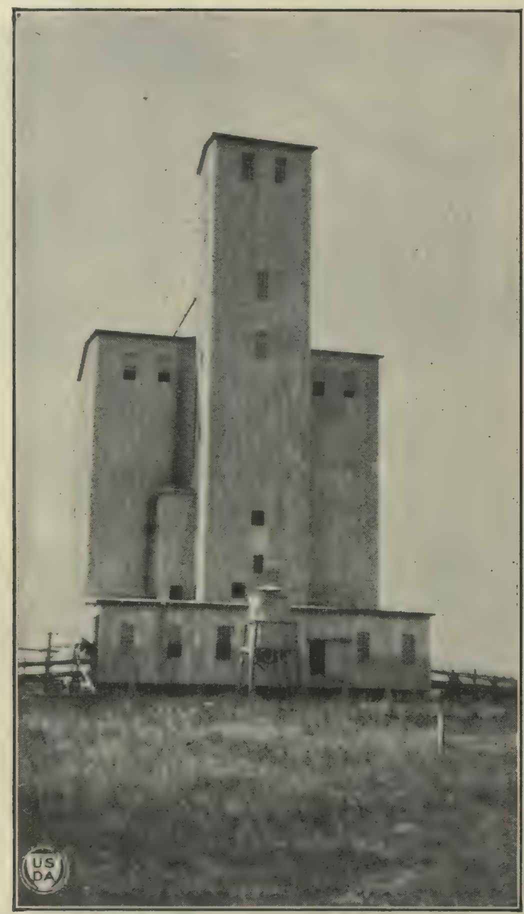

FIG. 17.—An elevator located at a country point used for storage of rice in bulk. This plant is equipped to receive bulk rice from farmers' wagons, to clean foreign material from the rice, to store the rice in large bins, and to load the rice in bulk into railroad cars for shipment to the mills or terminal markets.

These openings may be made weatherproof and still allow the air to pass by placing louver boards in them. These boards have sufficient overlapping to prevent the entrance of rain. The space between boards should not exceed 3 inches. In buildings where it is not possible to construct such top openings a cupola on top of the roof will serve practically the same purpose if provided with louvers.

In bins constructed on these lines, when not more than 8 to 12 feet in depth, there is a natural circulation of air which is usually sufficient to keep rice in good conditon, but if means for forcing a draft through the grain can be devised economically it is highly desirable. This has been done by inclosing the space under the bin except for one opening and placing a fan of some kind in this opening. Forced aeration is especially beneficial to damp rice.

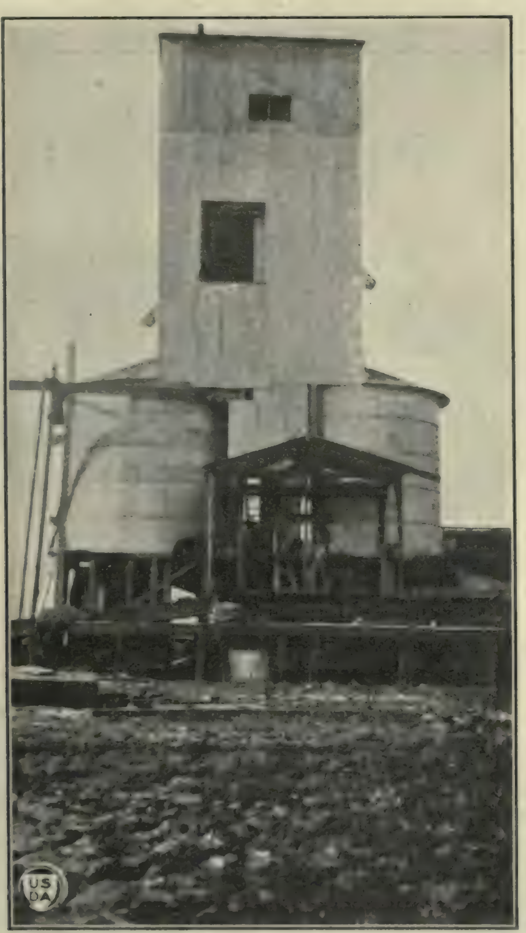

FIG. 18.—A farm elevator erected at a country siding for the purpose of recleaning rice and of providing temporary storage and as a means of loading bulk rice into cars.

Damp bulk rice should be stirred occasionally to prevent heating. This may be done readily in elevators where there is machinery for transferring the grain from one bin to another, but in farm storage it is usually more difficult. However, the elevating machinery with which the grain is put into the tanks or granaries can sometimes be utilized to advantage in transferring the rice. (Fig. 19.) It is well to put a blast of cool air on the rice at the time of transfer to cool it if it has begun to heat. Aeration can often be accomplished by dropping or "running" the rice through the driveway of a granary, or by transferring it from bin to bin or from tank to tank in the open air. Rice that is cool and in good condition should never be run in humid air or in air that is warmer than the rice, for in the first case the rice is likely to take on moisture from the humid air and in the second case the temperature of the rice is raised.

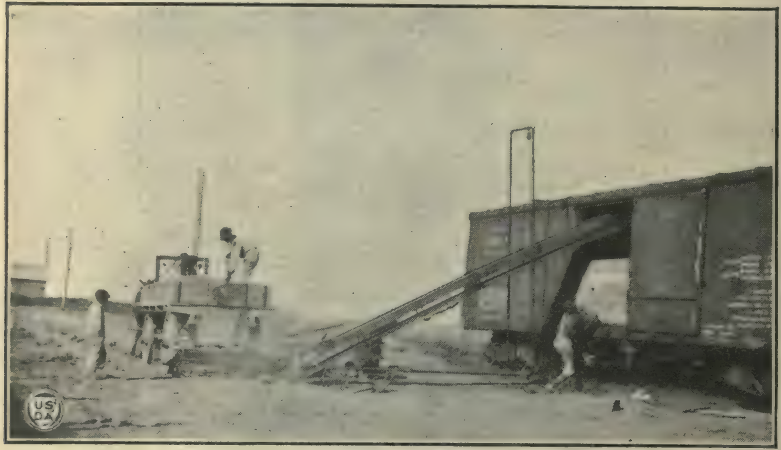

FIG. 19.—Loading bulk rice into a car for shipment at a country siding where there is no elevator. The loading apparatus is driven by a small gasoline engine and can also be used for putting rice into granaries or for transferring rice from one storage bin to another.

MOISTURE CONTENT FOR SAFE STORAGE.

Moisture content of rough rice is a prime factor in determining its keeping qualities in storage. The temperature and humidity of the air also play an important part. A moisture content that may be safe for storage under some conditions may not be safe under other conditions. Therefore, the maximum moisture content for safe storage varies with conditions. It is the consensus of opinion that a moisture content of 14.5 per cent is the maximum limit for safe storage under ordinary conditions in the southern territory. This percentage may be too high for safe-keeping in storage for long periods under unfavorable conditions. On the other hand, rough rice with a moisture content exceeding 14.5 per cent may sometimes be stored with safety if the conditions are very favorable.

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U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1421

SUCCESSFUL FARMING ON EIGHTY-ACRE FARMS IN CENTRAL INDIANA

THIS BULLETIN is primarily a story of the organization and management of successful 80-acre farms in central Indiana and adjacent areas which are following the type of farming that prevails in that part of the country.

Corn, oats or wheat, and clover or clover and timothy are the principal crops in this area. The small grains are mostly sold from the farms as cash crops, and the corn and clover (both hay and pasture) are fed to hogs, cattle, work animals, and poultry, hogs getting much the largest share.

Some of the leading principles of good farm organization and management on 80-acre farms are illustrated by the facts brought out regarding what the successful farmers on 80-acre farms have accomplished, not in a single year but over a series of years.

The bulletin sets before the 80-acre farmers who are following the prevailing type of farming standards which some farmers have reached and which are believed to be within the reach of a great many other 80-acre farmers in central Indiana and adjacent areas.

While it is recognized that farms larger than 80 acres offer greater opportunities for profits to capable managers, the fact that 80-acre farms are so numerous in this area is the reason for considering them by themselves in this publication. Data are available in the Department of Agriculture for discussions of the organization and management of 120-acre farms, 160-acre farms, and 240-acre farms.

Washington, D. C. Issued July, 1924

SUCCESSFUL FARMING ON EIGHTY-ACRE FARMS IN CENTRAL INDIANA.

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WHAT ARE the opportunities for success on 80-acre farms in central Indiana?

What cropping systems are most profitable?

What is the best arrangement of fields?

What crop yields are favorable for good profits?

What kinds of livestock and how much of each are most desirable on farms of this size?

What production should be expected from the various kinds of livestock?

What machinery and equipment is economical for the efficient operation of 80-acre farms?

These are some of the questions discussed in this bulletin.

Within the portion of Indiana to which this bulletin particularly applies (fig. 1) there are approximately 98,000 farms. Of this number about 31,000, or almost one-third of the total, are between 50 and 99 acres in size, and about 20,000 of these are approximately 80 acres in size. The success in securing reasonable returns for the labor and capital on each of these farms depends largely on how the operator answers the above questions.

INCOMES MADE ON 80-ACRE FARMS.

Since 1910, Purdue University and the United States Department of Agriculture have obtained business records showing the farm profits under the various systems of management from over 1,700 farmers in central Indiana. About 340 of these records were from approximately 80-acre farms. In general, these records show that on an average, over a period of years, operators of 80-acre farms make about a mortgage rate of interest on their capital and somewhere near a hired man's wages for their labor, in addition to securing the products furnished by the farm for the family living and a possible increase in value of the farm land owned. Figures from twenty 80-acre farms in Clinton County for eight years given in Table 1 are representative of the region.

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[1] This study was made in cooperation with the Extension Service of Purdue University.

Receipts are the value of all the products sold from the farm, plus any increased value of livestock due to growth or increase in numbers and plus the value of any increased quantity of feed at the end of the year over the beginning of the year.

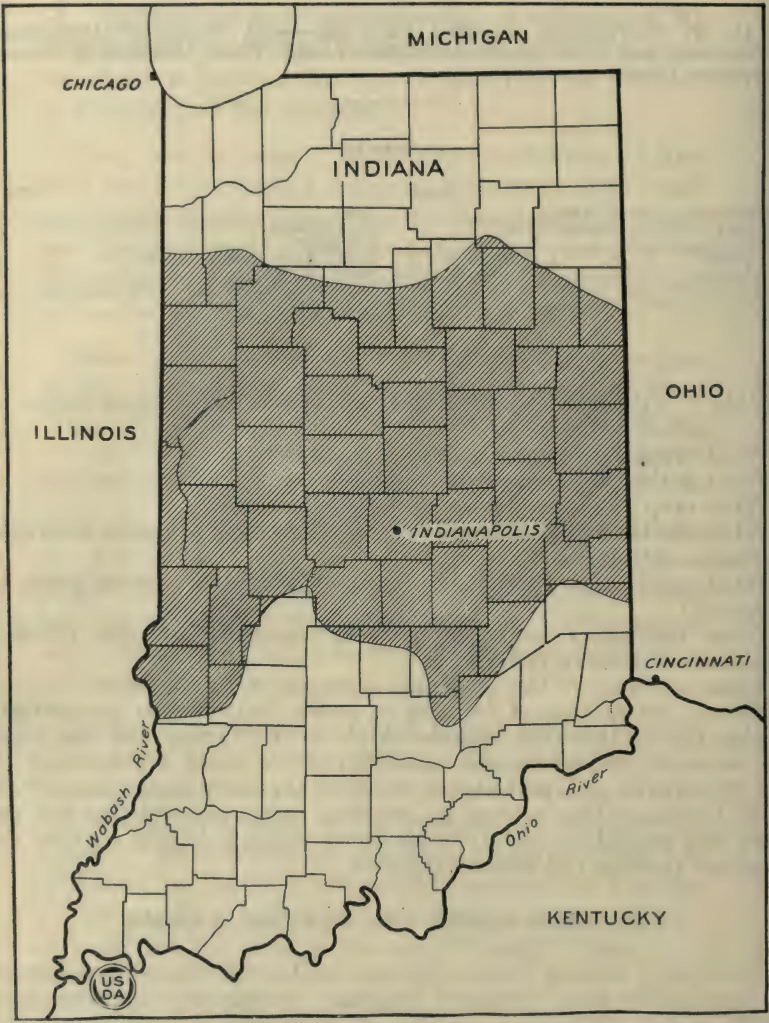

FIG. 1.—The shaded portion of the map shows the part of Indiana to which the discussion in this bulletin particularly applies.

The farm income is the receipts less the expenses (the expenses including all costs except any charges for the farmer's own labor and for interest on the capital), and represent the combined returns

Table 1.—*Average receipts, income, and value of family living from twenty 80-acre farms in Clinton County, Ind.*

Year.	Receipts.	Farm income.	Labor income.	Per cent on capital.	Value of family living furnished by farm.
1910	$1,396	$953	$319	5.1	$278
1913	1,423	954	171	4.1	257
1914	1,342	771	−20	2.8	222
1915	1,461	850	50	3.4	236
1916	1,981	1,377	588	6.7	290
1917	2,238	1,342	514	5.9	355
1918	2,808	1,817	867	7.2	445
1919	2,638	1,539	564	4.8	441
Average for eight years	1,911	1,200	382	5.0	316
Average of the four most successful farms	2,527	1,566	622	6.2	350
Average of the four least successful farms	1,368	663	−62	2.0	303
Average of the most successful farm	3,097	1,722	757	6.9	331
Average of the least successful farm	774	196	336	−.6	303

for the use of the capital and the farmer's labor, exclusive of the family living furnished by the farm.

The labor income is the farm income less 5 per cent interest on the capital. It represents the pay the farmer gets for his year's labor, exclusive of any of the family living furnished by the farm.

The per cent on capital is the farm income less the value of the farmer's own labor and expressed as per cent of the capital. It represents the returns to capital after allowing the farmer's estimate of the value of his own labor.

The family living furnished by the farm, varying in value at farm prices in different years from $222 to $445, represents the meat, milk, eggs, fruit, vegetables, etc., set aside from the farm production for family use and the fuel and house rent furnished by the farm. The importance of these items of family living from the farm is often overlooked by farmers when figuring how much their farms have returned them.

VARIATION IN INCOMES ON 80-ACRE FARMS.

While the average 80-acre farmer receives a moderate return for his capital and labor, there is a wide variation in the profits made by different farmers. As an example, the most successful 80-acre farmer in the Clinton County group for which figures were presented in Table 1 received an average farm income of $1,722 per year for eight years as compared to $196 per year received by the least successful of the 80-acre farmers.

A comparison of the four most successful 80-acre farms with the four least successful 80-acre farms in a community shows some of the reasons for the greater success of some farmers than of others. The discussion following is based upon the results from all of the 80-acre farms in central Indiana from which records have been secured, and is frequently illustrated with facts from the four most successful and the four least successful of the 80-acre farms in the Clinton County area.

THE CROPPING SYSTEMS.

A few acres on every 80-acre farm are taken up with woods, lanes, building sites, lots, gardens, etc. From 4 to 10 acres, on at least three out of every four farms originally covered with timber, are in woods pasture, and on most farms, whether there is woods pasture or not, there are a few acres in permanent pasture, alfalfa, or some other crop, grown outside of the regular rotation land. The rotation land, therefore, seldom exceeds 70 acres, is usually from 60 to 70 acres, and sometimes less than 60 acres.

The outstanding cropping system on the 80-acre farms in this area is built around a three-year rotation of corn, small grain, and clover with timothy. Other less common systems are—a four-year rotation of corn, corn, small grain, and clover with timothy; a four-year rotation of corn, small grain, small grain, and clover with timothy; a four-year rotation of corn, small grain, clover with timothy, and clover with timothy; and a five-year rotation of corn, corn, soybeans, wheat, and clover with timothy.

Successful farmers want all the land in corn that they can well care for and still have a good cropping system from the standpoints of the efficient use of labor, of crop rotation, and of the productivity of the land. For example, the four most successful farms already referred to averaged 27 acres in corn, 18 acres in small grain, and 20 acres in clover with timothy, or 27 acres in corn out of a total rotation area of 65 acres.

TABLE 2.—*Acres in crops on four of the most successful 80-acre farms in Clinton County—eight-year average.*

	Corn.	Small grain.	Clover with timothy.	Total rotation.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Farm 1	36	14	19	69
Farm 2	24	19	19	62
Farm 3	26	23	20	69
Farm 4	23	18	21	62

If the 3-year rotation system (see fig. 2) were followed to the letter, most of the 80-acre farmers would have from 20 to 23 acres in each crop each year, or less than they want in corn, and less than they usually have. More corn than is afforded by the strictly 3-year rotation plan is often secured through modifications of this plan, the more common of which are:

(*a*) Some farmers with the 3-year rotation have a field of from 5 to 10 acres, aside from the rotation land, on which corn is grown continuously and "hogged off." These farmers think that under this treatment the land becomes better each year. In recent years soybeans are often planted with corn. This is to be commended for all the land in corn whether or not the corn be "hogged off."

(*b*) Clover and timothy seedings sometimes fail. When the seeding fails, the land is sometimes put in corn, and the intended 3-year rotation of corn, small grain, and clover with timothy is lengthened temporarily into a 5-year rotation of corn, small grain, corn, small grain, and clover with timothy. This practice is favored

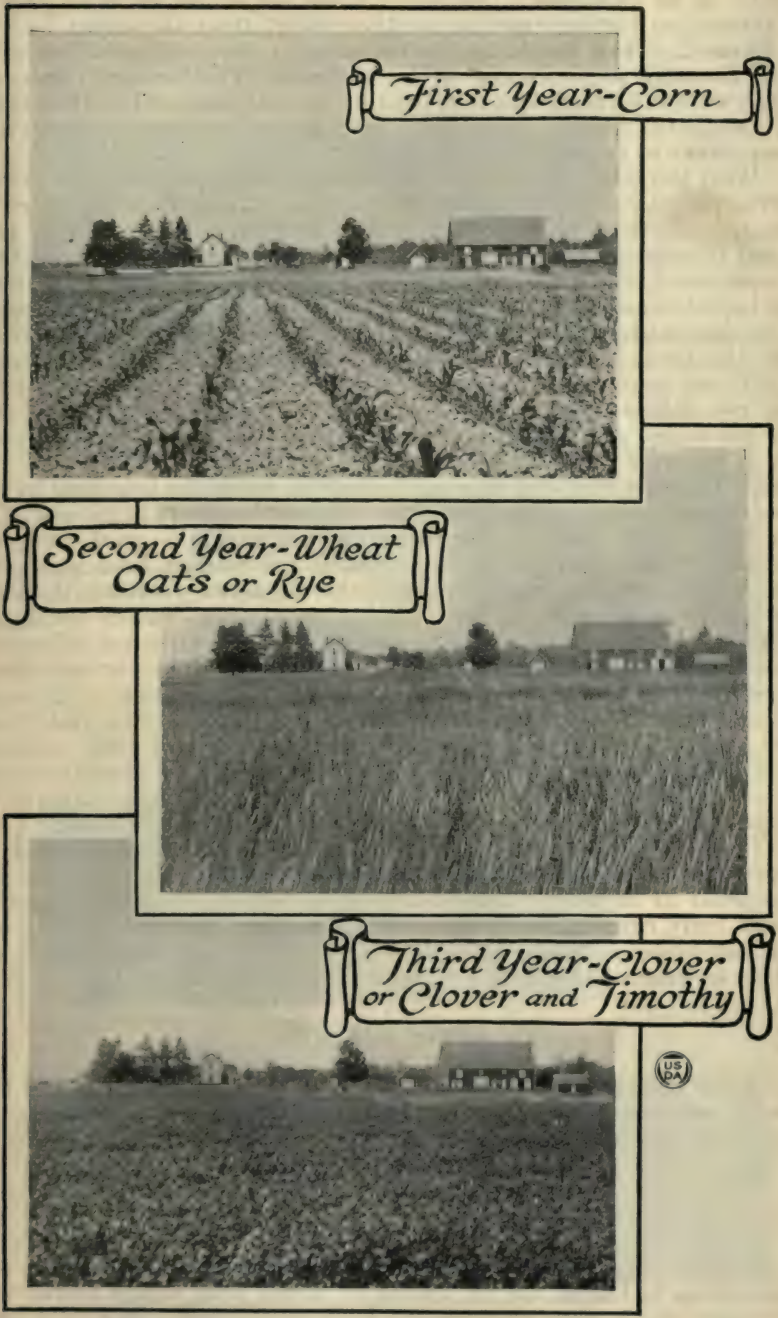
First Year-Corn
Second Year-Wheat Oats or Rye
Third Year-Clover or Clover and Timothy

FIG. 2.—The usual cropping system on 80-acre farms in central Indiana.

only as an emergency practice. These somewhat common clover failures are further reaching in their effect than the direct loss of the seed. They break up the cropping system and interfere with the livestock organization of the business. The farmer is face to face with the questions: What shall I do with the land? How shall I handle my stock? Wise decisions relating to these questions are important to successful management.

With the four-year rotation of corn, corn, small grain, and clover with timothy (fig. 3), practiced by a few 80-acre farmers, there is more corn than in any other of the rotation systems. With less land in rotation pasture than in the three-year system, this system requires a little more land in permanent pasture, if enough livestock is kept to consume all the corn. Objections to this four-year rotation are made on the grounds that two years in corn are too hard on the land. It is favored by those practicing it on the ground that two years in corn after a good clover sod and on strong land do not reduce yields, surely not when the corn is "hogged off" one of the years, and when the stalks are plowed under and not burned.

A five-year rotation of corn, corn, soybeans, wheat, and clover with timothy (fig. 4) is a cropping system which is practiced by an occasional farmer within this area. It is favored on the ground that it closely approximates the principles underlying a good cropping system. With this system two-fifths of the rotation land is in corn each year, affording more corn than the three-year rotation; the land is in leguminous crops two years in five, which favors both soil fertility and the feeding ration, and the problem of clover failures is lessened, only one-fifth of the land being seeded to clover each year, against one-third of the land in the three-year rotation. The soybeans may be harvested either for hay or for grain. The grain may be sold as seed or used for feed. Their use for feed gives a better ration than if corn alone is fed; or, if protein feeds are used, it lessens the expense for such feeds. This system requires a little more land in permanent pasture than the three-year rotation system.

Cropping systems with only one-fourth of the rotation land in corn are practiced by a few 80-acre farmers. These systems are objected to on the ground that they do not afford enough land in corn (only from 15 to 17 acres on most farms) for the efficient use of man labor and horse labor, or for feed for the amount of livestock kept on most of the more successful 80-acre farms.

CROP YIELDS.

Much the same cropping systems, that is, the same crops and the same acreages of each, prevailed on the least successful farms as on the most successful farms, but the higher yields per acre on the most successful farms gave them considerably larger total crop production.

While high crop yields are not absolutely essential to successful farming, yet practically all of the more successful farms have yields above the average of the community. But the mere fact that a farm has yields above the average does not guarantee its success, for numerous instances are on record of farms with yields above the average which were unsuccessful because the crops were not efficiently marketed through livestock.

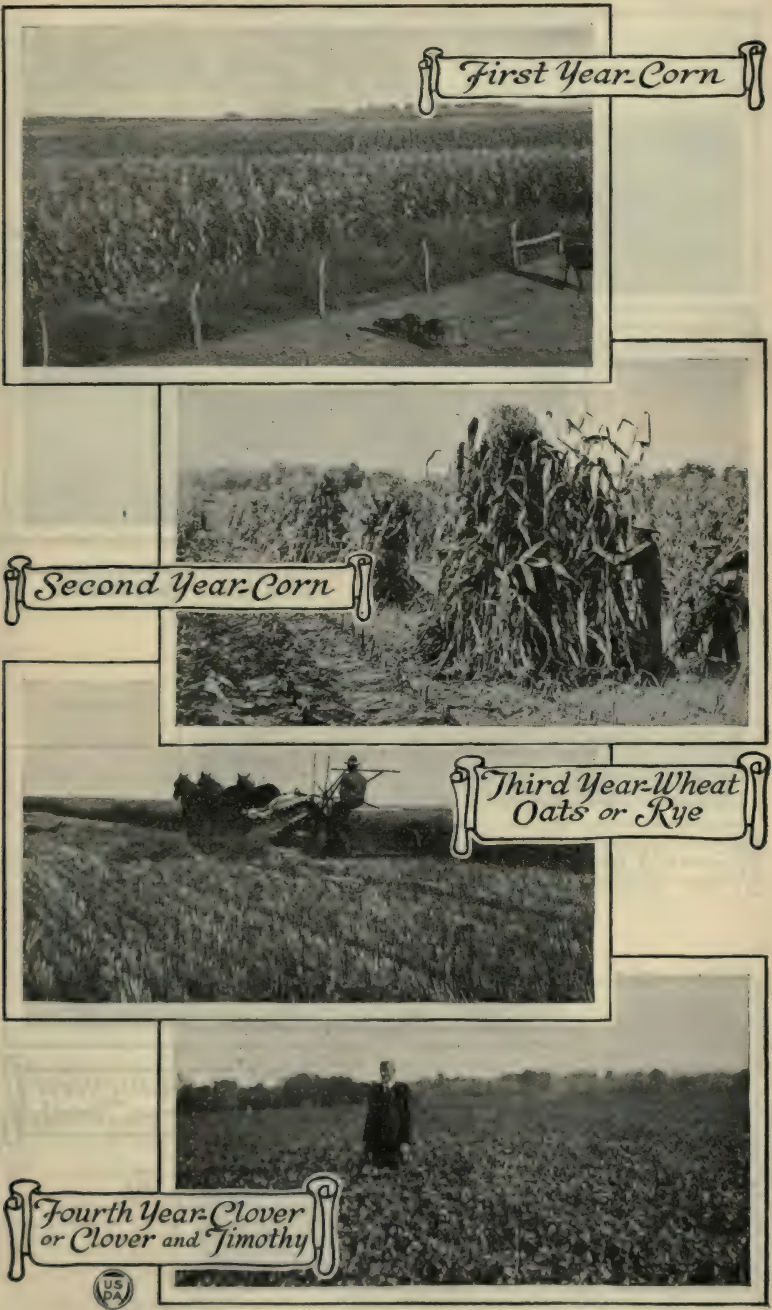
First Year-Corn
Second Year-Corn
Third Year-Wheat Oats or Rye
Fourth Year-Clover or Clover and Timothy
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FIG. 3.—The cropping system on a few 80-acre farms in central Indiana.

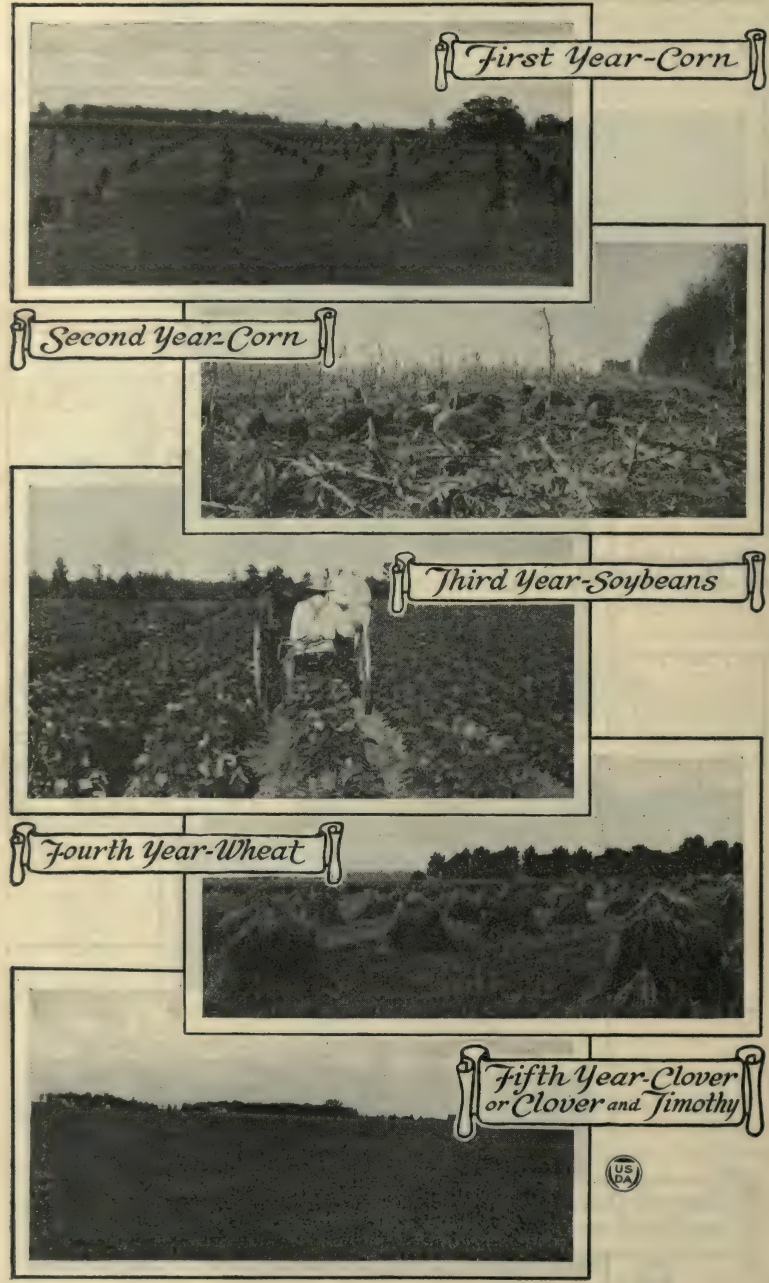


FIG. 4.—The cropping system on an occasional 80-acre farm in central Indiana.

TABLE 3.—*Yields per acre on four of the most successful and four of the least successful 80-acre farms in Clinton County—eight-year average.*

	Corn.	Oats.	Wheat.	Hay.
	Bushels.	*Bushels.*	*Bushels.*	*Tons.*
Farm 1	45	43	20	1.6
Farm 2	50	45	18	1.4
Farm 3	49	46	20	1.4
Farm 4	49	45		1.3
Average of the four most successful farms	48	45	19	1.4
Farm 5	42	34	([1])	1.1
Farm 6	36	34	([1])	1.4
Farm 7	46	39	([1])	1.3
Farm 8	39	40	([1])	.7
Average of the four least successful farms [1]	41	37	([1])	1.1

[1] The fact that wheat was not raised on any of the four least successful farms had no appreciable bearing upon their incomes. Of the most successful farms which were raising wheat one had wheat two years; another three years; and the other four years of the eight. Oats or wheat, at the option of the farmers, was grown the one year between corn and clover. Growing small grains on the same land for two successive years was quite uncommon.

FARM LAYOUTS.

Many 80-acre farms, particularly in regions originally covered with forests, are fenced into fields in such a way that the uniform crop rotation most desirable can not be followed. Inconvenient farm layout is nearly as great a cause of variation in acres of the different crops from year to year as is clover failure. The only layout that will permit the ordinary three-year rotation to be practiced is one in which the crop land is divided into three fields of nearly equal size, or one in which various smaller fields can be grouped in such a way that there is about an equal area available for each of the three crops in the rotation. Similarly a four-year rotation should have four fields of nearly equal size and a five-year rotation five fields.

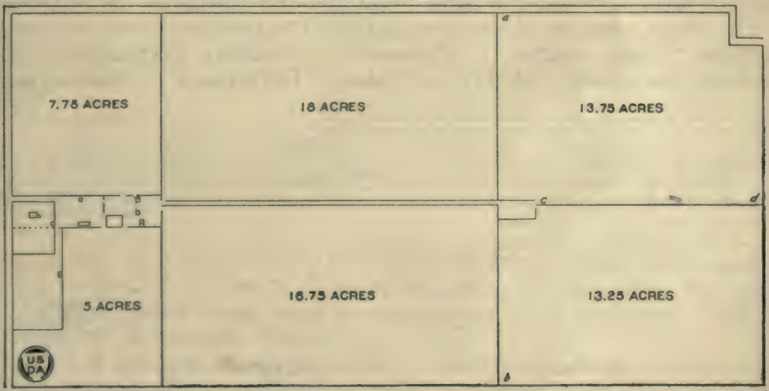


FIG. 5.—Layout of an 80-acre farm in Clinton County. This is one of the most successful farms, but the operator recognizes the handicap he is working under in trying to follow a 3-year rotation on the four large fields. The two fields near the buildings are being used for alfalfa and permanent pasture. The simple change shown in Fig. 6 appealed to the farmer as the solution of his problem of rearrangement to obtain a better layout for a 3-year rotation.

Fields of large size, rectangular in shape, and from one and one-half to three times as long as wide are most economical from the standpoints of fencing costs and convenience in operating. Laying out the farm in such a way that fields corner as near as possible to the farm buildings saves labor in going to and from fields, reduces the amount of lanes necessary and facilitates the care of livestock.

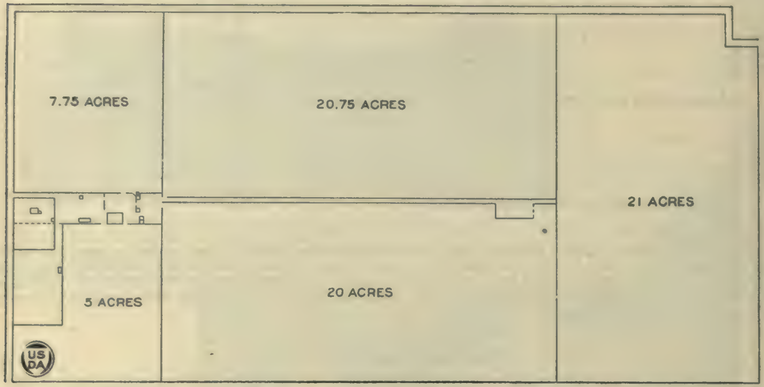


FIG. 6.—The same farm as shown in fig. 5 with improved layout. By moving the cross fence (*a*, *b*, in fig. 5) 13 rods toward the rear end of the farm and removing another fence (*c*, *d*, in fig. 5), three fields of nearly equal size are provided and 43 rods less fence are required. This arrangement will require only 418 rods of interior fence, which is less than is found on most 80-acre farms.

Some farmers are eliminating lanes by maintaining a permanent pasture field between the farm buildings and the more distant fields.

The large number of hogs and other livestock on farms in central Indiana usually makes it advisable to maintain permanent fences between the various established fields. Differences in field arrangement on various 80-acre farms frequently result in a variation in the amount of inside fence required of from 425 rods to over 700 rods.

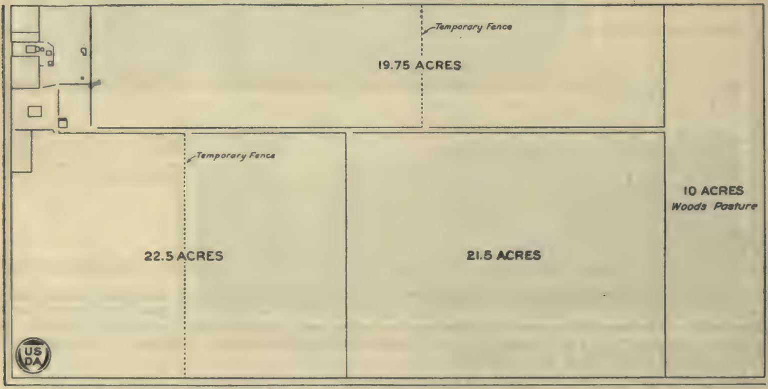


FIG. 7.—A good layout on an 80-acre farm. Unfortunately the uncleared woodland is at the opposite end of the farm from the buildings. This is typical on 80-acre farms in central Indiana. This farm has three large fields of nearly equal size, permitting a 3-year rotation of corn, wheat, and clover. A temporary fence is stretched each year across the field which is in clover, so that part of it may be pastured and part cut for hay. A temporary fence is also stretched across the field in corn when part of it is "hogged off."

The accompanying layouts on several different farms (see figs. 5 to 11) bring out some of the important facts to consider in the division of an 80-acre farm into fields for most efficient management.

WHAT LIVESTOCK IS DESIRABLE.

The 80-acre farm in central Indiana that is profitable over a period of years usually has enough livestock of good quality to consume all the corn grown on it and often some purchased corn. The four most successful farms from which records were obtained for eight years in Clinton County had 54 per cent more livestock than the four least successful farms. In most cases hogs are the most important class of livestock on the 80-acre farms. There are opportunities for making dairying or poultry raising a larger part of the farm business than is common in this area, and a few men are making good profits from dairy cows and chickens, but the better-paying farms obtain the largest livestock receipts from hogs. A good combination of livestock, such as was found on the most successful Clinton County farms (fig. 12) is 3 to 5 dairy cows, with enough young cattle to maintain the herd; 5 to 8 brood sows, from which 50 to 70 pigs are raised each year; 100 or more hens, and the necessary work animals. A few ewes are found on some farms.

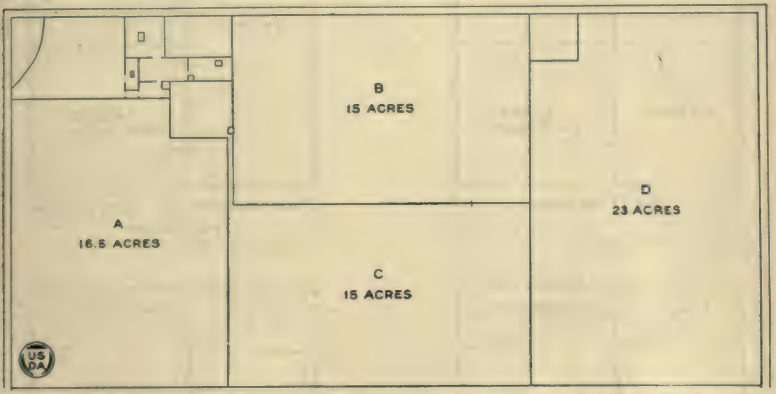
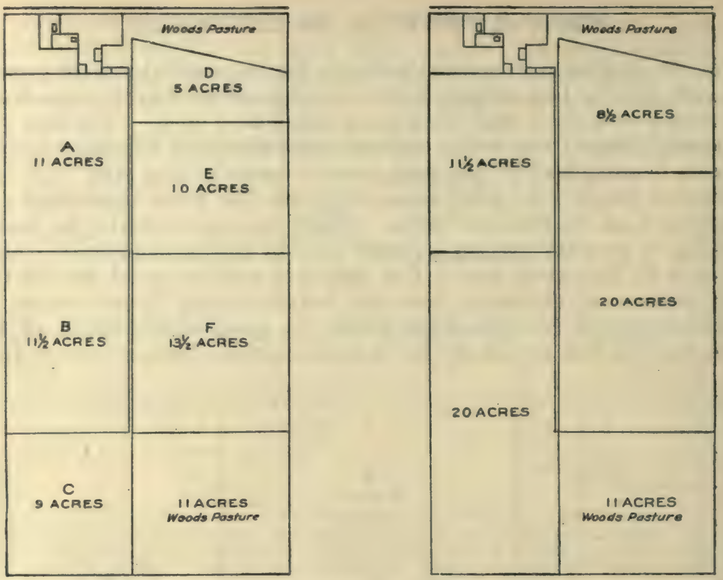


FIG. 8.—Field arrangement on a successful 80-acre farm in Clinton County. On this 80-acre farm a 3-year rotation is followed on fields A, B, and C, and field D, on which the same rotation is practiced, is divided into three parts—without interior fencing. The bigger clover field is pastured and the one-third of field D, which is in clover, is cut for hay. The parts of field D which were in corn have been "hogged off" for several years.

On one of the four most successful of the 80-acre farms all the corn that was raised and over 500 bushels of purchased corn were fed each year, and on another of these farms over 200 bushels of corn were purchased each year. On an average the four most successful farms had enough livestock to consume over 1,300 bushels of corn each year as compared to less than 900 bushels on the four least successful.

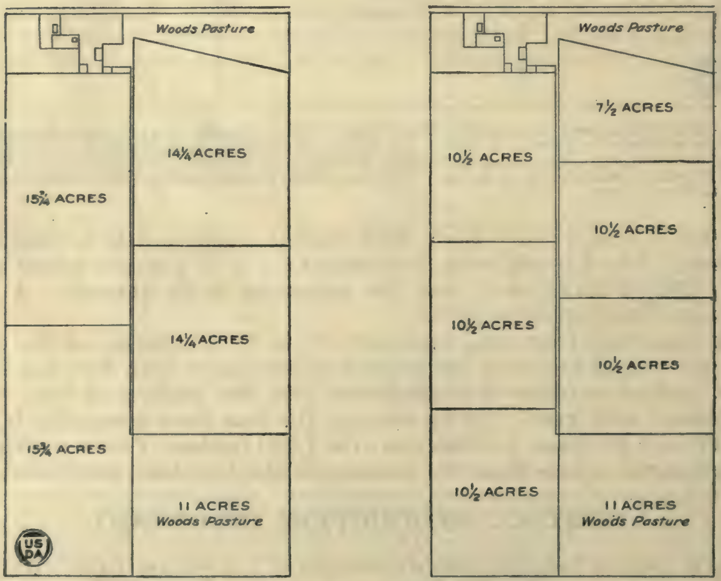
LIVESTOCK PRODUCTION IMPORTANT.

Farm records indicate that differences in the returns from livestock cause greater variations in farm incomes than any other item. The successful farmers have a good quality of livestock, feed better rations, and give better care than the unsuccessful farmers. In the Clinton County area the most successful 80-acre farmers raised an average of 9.3 pigs per sow each year as compared to 6 pigs (two litters) per sow by the least successful farmers. In the case of other livestock, there



As it is now

Rearranged for three-year rotation.



Rearranged for four-year rotation

Rearranged for five-year rotation

FIG. 9.—An 80-acre farm as it is, and with improved layouts for 3, 4, and 5 year rotations. This very successful farm used a 3-year rotation. By combining fields D and F, fields B and C, and fields A and E, 18½, 20½, and 21 acres were used for the three crops. This layout required 610 rods of fence. The three other plans show how this farm might be more conveniently arranged for 3, 4, and 5 year rotations. When rearranged for a 3-year rotation, the 8½-acre and the 11½-acre fields are considered as one field in the rotation, and when rearranged for the 5-year rotation the 7½-acre field is to be used for crops outside of the rotation. In the 3 and 4 year plans 79 rods of fence are saved over the original plan.

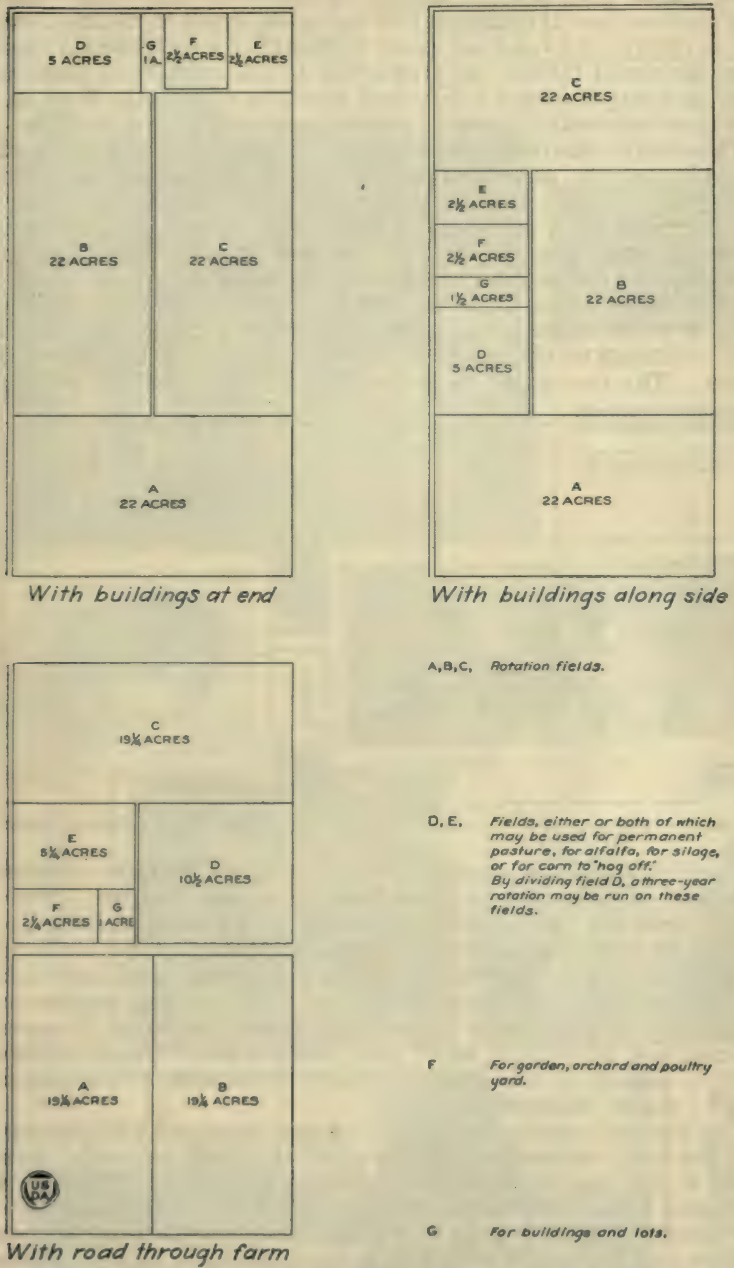

D
5 ACRES
G
1 A.
F
2½ ACRES
E
2½ ACRES
B
22 ACRES
C
22 ACRES
A
22 ACRES
With buildings at end
C
22 ACRES
E
2½ ACRES
F
2½ ACRES
G
1½ ACRES
D
5 ACRES
B
22 ACRES
A
22 ACRES
With buildings along side
C
19¼ ACRES
E
5¼ ACRES
D
10½ ACRES
F
2¼ ACRES
G
1 ACRE
A
19¼ ACRES
B
19¼ ACRES
With road through farm
A, B, C, Rotation fields.
D, E, Fields, either or both of which may be used for permanent pasture, for alfalfa, for silage, or for corn to "hog off."
By dividing field D, a three-year rotation may be run on these fields.
F For garden, orchard and poultry yard.
G For buildings and lots.

FIG. 10.—Suggestive layouts for a 3-year rotation on 80-acre farms. It may be impracticable on many farms on account of ditches, streams, woodlands or other conditions to have fields of the exact size and shape suggested in these layouts, but on most farms some changes can be made that will make the field arrangement approximate the ideals illustrated in this figure.

were similar differences in the production of young stock. On the four most successful farms one calf was raised every 12 months for each cow as compared to one calf every 15 months for each cow on the four least successful farms. In proportion to the number of hens kept, twice as many chickens were raised to sell or replace the flock on the four most successful farms as on the four least successful farms.

The cows on the four most successful farms averaged 172 pounds of butterfat per cow, as compared to 82 pounds on the four least successful farms. The production, even on the most successful farms, was low for dairy cows, but some of these cows were of the beef or dual-purpose type. Egg production per hen in the former group of farms was 53 per cent higher than in the latter group.

Most home-raised feeds are low in protein, and best results are secured when supplements such as tankage for hogs and chickens and cottonseed meal or oil meal for cattle are used to balance the feed ration. The four most successful farmers purchased an average of three-fourths of a ton of protein supplement per year as compared to one-third of a ton by the four least successful farmers. Many of the farmers are now utilizing soybeans as a source of home-grown protein to help balance the cattle and hog rations. Soybeans are a good substitute for linseed-oil meal or cottonseed meal for cattle or for tankage for hogs when supplemented with a mineral mixture made of 10 parts of wood ashes or finely pulverized limestone, 10 parts 16 per cent acid phosphate, and 1 part common salt. One hundred and seventy pounds of this mixture plus 2,400 pounds of soybeans will equal 1 ton of tankage.

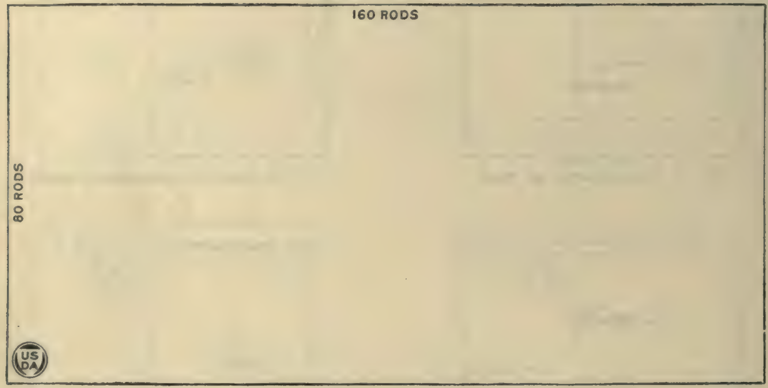


FIG. 11.—Map the layout of your own 80-acre farm. Can you improve on your present layout?

The four most successful 80-acre farmers averaged $28 expense per year for hog vaccination, while one of the least successful farmers spent $7 per year and the other three spent nothing. The four most successful farmers averaged less than 1 hog lost per year and the least successful farmers 5 hogs per year. One of the least successful farmers lost 38 hogs from cholera in a single year. The differences in hog losses much more than paid the cost of vaccination.

On the two of the four most successful Clinton County farms from which the largest number of eggs were sold, the poultry housing conditions were far above the ordinary. A large production of winter

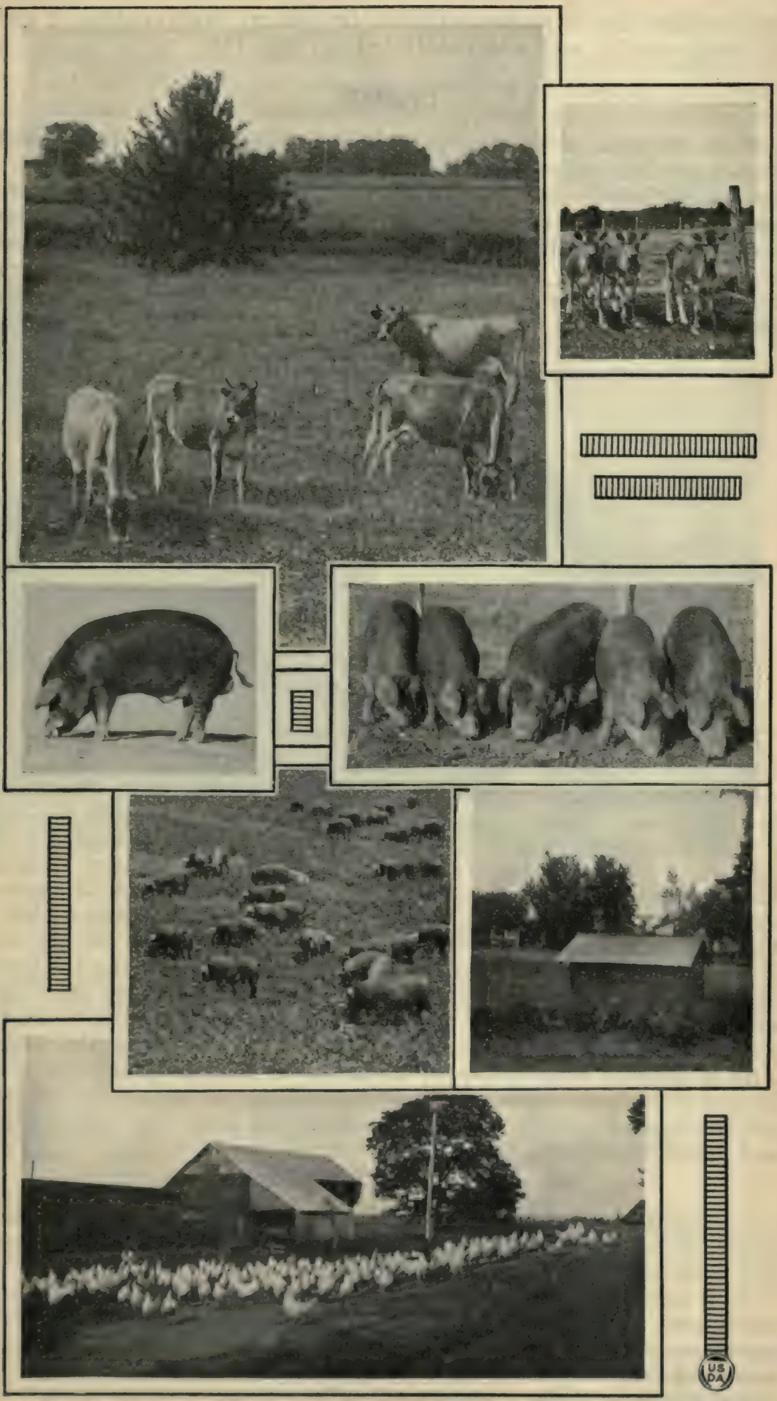


FIG. 12.—The combination of livestock prevalent on many of the more successful 80-acre farms.

eggs requires a poultry house that is dry, roomy, well-ventilated without being drafty, and adequately lighted (fig. 14).

LABOR.

With the type of farming prevailing in this area, the farmer with the aid of his family or a little hired labor, performs all the labor on the 80-acre farm. Members of the family often help with the chores, and during rush periods the farmers often hire some extra labor. In all, the labor in addition to the farmer's own labor, usually amounts to from two to four months. On at least half of the 80-acre farms this is performed by members of the farmer's family, and no hired labor is required.

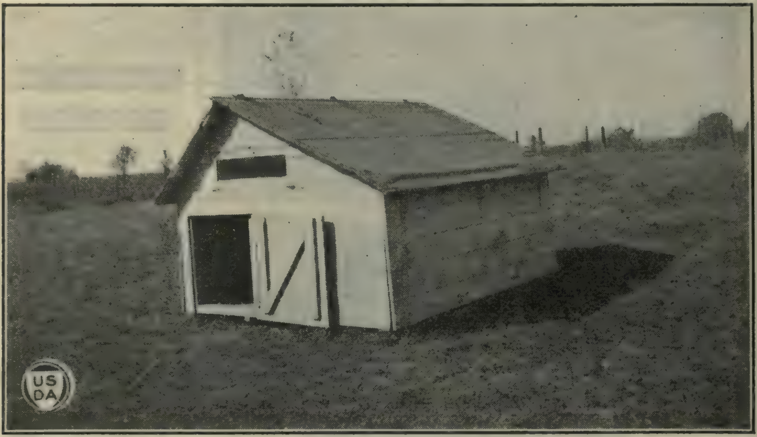


FIG. 13.—Individual hog houses are more satisfactory than the centralized hog house on 80-acre farms.

Using labor advantageously is important to successful farming. There are instances of one man tending as low as 10 to 15 acres of corn, on an 80-acre farm, and others of one man tending as high as 25 to 30 acres (fig. 15). Much more livestock is cared for per man on some farms than on others. There is a tendency among the better 80-acre farmers to reach out just a little farther and farm more land with the labor which is used on the 80 acres, sometimes without any additional capital in work animals or machinery. When the 80-acre farm is already well-equipped, instances of farmers going out of the 80-acre class and farming from 10 to 40 acres of additional land are not uncommon. Sometimes this additional land has been bought and sometimes rented.

WORK ANIMALS.

From three to four work animals are kept on most of the 80-acre farms, three prevailing on the more successful farms and four on the less successful ones (Fig. 16).

Four horses are needed for certain operations with certain types of machinery, such as the use of a double-disk harrow, but most of the more successful farmers agree that they are not justified in keeping more than three 1,400 to 1,500 pound horses, unless some of them are brood mares or there is team work off the farm.

EQUIPMENT.

While the most successful farms are equipped with better machinery and of a higher type than the least successful ones, they are not overequipped and have less machinery than a great many other 80-acre farms. In fact, the judgment of the most successful farmers is that many 80-acre farms are overequipped, that the capital in machinery is too high for its economical use. The machinery equipment for an 80-acre farm requires careful consideration, and the following list has been prepared for 80-acre farms, after considering the machinery actually owned on forty 80-acre farms and interviewing several of the more successful 80-acre farmers in Clinton County:

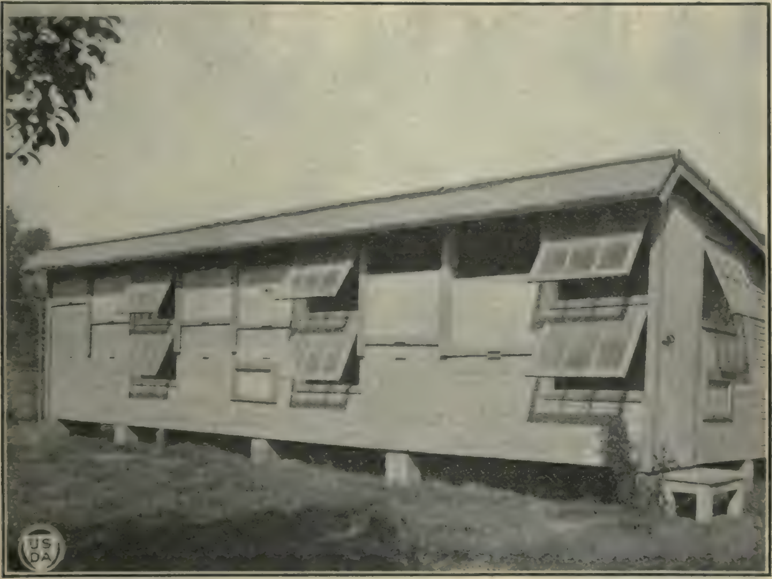


Fig. 14.—The poultry house recommended by Purdue University for farms in this area. The building may be 16 by 24 feet, or 20 by 20 feet and is large enough for 100 hens. The poultry department of the university favors the 20 by 20 feet house on farms where there is apt to be an extension in the poultry business. Construction plans for poultry houses are available through the Extension Service of Purdue University. (Photo by Poultry Department, Purdue University.)

Machinery for an 80-acre farm in central Indiana.

Wagon.
Walking plow, 14-inch.
Sulky plow, 14-inch.
Disk harrow, 7-foot.
Spike-tooth harrow, 2 sections (10 feet).
Packer (double), 8-foot.
Corn planter, with fertilizer and soybean attachment.
Corn cultivator, 1-row or 2-row.
Grain binder, 6-foot to 8-foot.
Grain drill, 1, 2, or 3 horse, with fertilizer attachment.
Mower, 5-foot.
Hay rake, 10-foot.
Gas engine, for pumping water, etc.
Corn sheller, hand.
One-horse cultivator.
Incubator.
Cream separator, 375 pounds per hour for 2 to 5 cows.
Manure spreader, 50-bushel.
Work harness, for 3 horses.
Miscellaneous small tools.

In connection with this list it should be stated that some farmers are using such items of equipment as mowers, rakes, corn binders, and silage cutters jointly with neighbors. The machines are owned jointly, or one farmer owns one machine and another farmer owns another, thus reducing the capital requirement, depreciation, and repair expense for each farm. Arrangements of this sort are economical when the machines can be used on more than one farm without loss to the crops on any of the farms. Some 80-acre farmers

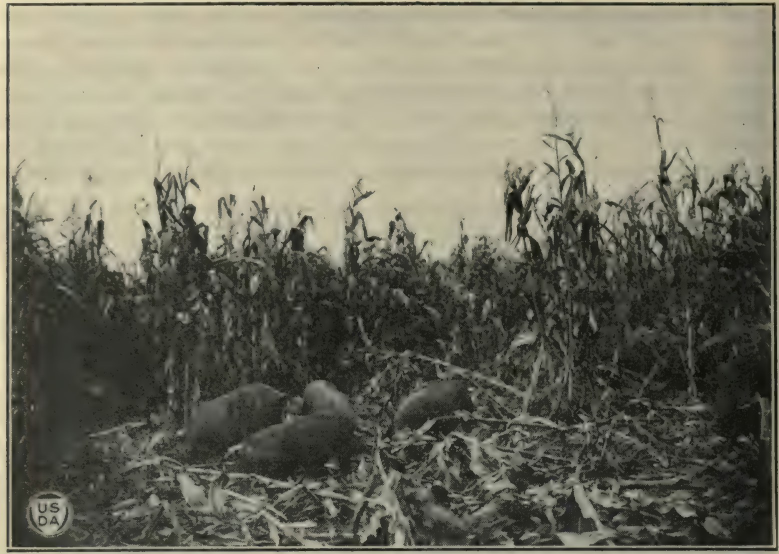


FIG 15.—A labor-saving practice, which has become popular on 80-acre farms. It's fun for the hogs and favors soil fertility.

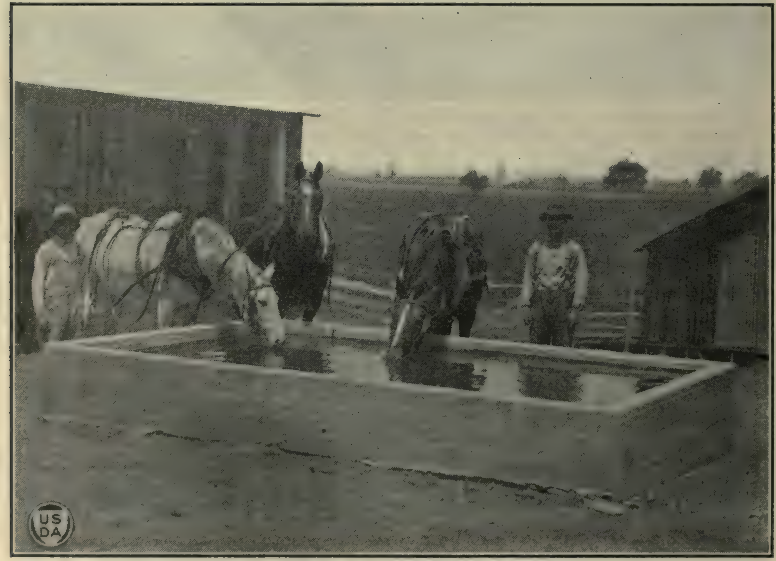


FIG. 16.—The work animals for an 80-acre farm.

have occasionally bought second-hand machinery at low prices which they would not have been justified in buying new.

Successful 80-acre farmers as a rule have an automobile which has sometimes replaced a horse, buggy, and driving harness. It often counts for greater efficiency of the farm operation and adds to the pleasure of the farmer and his family.

FAMILY LIVING ON 80-ACRE FARMS.

The value of the products furnished by the farm for family living is greater than is generally recognized. On the four most successful 80-acre farms in Clinton County from which records are available the farms contributed approximately the following amounts of products: Four hogs for meat, 50 chickens, 75 dozen eggs, dairy products to the equivalent of 100 pounds of butterfat, an acre of garden and fruit, 3 cords of wood, and a family dwelling house.

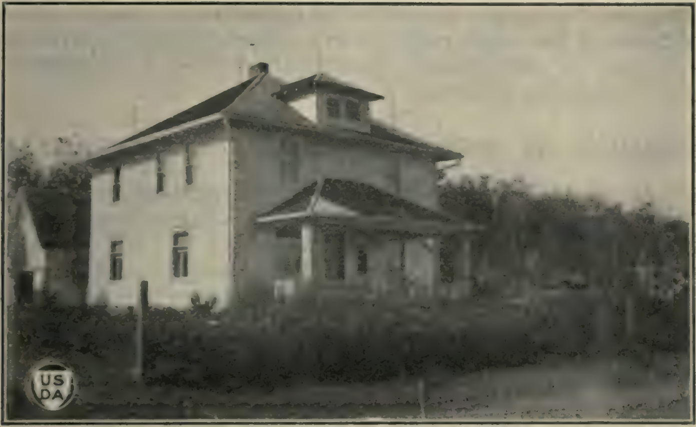


FIG. 17.—A modern home on a successful 80-acre farm. This home has electricity, furnace heat, hot and cold water, bath, and sewerage system.

On some of the more successful 80-acre farms in central Indiana there are comfortable houses with modern conveniences, including electric lights, running water, bathrooms, and furnaces (fig. 17). Some of the houses with electricity or other power use it for separating cream and making butter, for laundry work, or for housecleaning. It is the opinion of the owners of these farms that the money expended for such improvements has been a wise investment. Many of the more successful men from the financial standpoint are the most interested in those things that result in a higher standard of living in the farm homes. Their boys and girls are participating in club work and are being given educational opportunities at high schools and colleges.

SUMMARY.

A number of 80-acre farmers in central Indiana and similar adjacent areas "made good" over a series of years, while some of their 80-acre neighbors were receiving low returns from their land and labor. Opportunities for success come to those who maintain comparatively high standards of organization and management. In general, the more successful farmers had definite crop rotation systems of corn, small grain, and clover and timothy, with a tendency to put more land in corn whenever practicable. Over a series of years yields as high as 50 bushels of corn, 45 bushels of oats, 20 bushels of wheat, and 1.5 tons of hay per acre were obtained. From three to five dairy cows with enough young cattle to maintain the herd; from five to eight brood sows, raising from 50 to 70 pigs per year; 100 or more hens; and three work animals were common. With good breeding, feeding, and care profitable production per animal (as of butterfat per cow, pigs per sow, and eggs per hen) was obtained.

The farmers themselves did most of the work, with members of the family helping with the chores. During rush periods the family helped with the farm work, or some one was hired. In all, the members of the family or persons hired performed from two to four months of labor. The farmers had the machinery necessary for efficient operation of their farms, but they did not invest in machinery which required so much money as to forbid its economic use. Successful farming was often reflected in comfortable homes with modern conveniences, in educational opportunities given the children, and in higher standards of living.

STANDARDS OF ORGANIZATION AND MANAGEMENT.

The following table of standards in farm organization and management under three, four, and five year crop rotation systems is given for the guidance of 80-acre farmers in central Indiana and adjacent areas. It is fully realized that conditions differ from farm to farm, and that no two farms are exactly alike in every respect. The standards, therefore, should be interpreted as subject to modifications to meet the conditions existing on each farm. Some modifications have been discussed.

To farmers on 80-acre farms who maintain standards on as high a plane as those in Table 4 over a period of several years success is almost certain.

TABLE 4.—*Standards of organization and management for successful farming on 80-acre farms under three, four, and five year crop rotation systems.*

	Three-year cropping system.	Four-year cropping system.	Five-year cropping system.	Your own farm.
Land:				
Farmstead, roads, lanes, etc. . . . acres	7	7	7	----------
Permanent pasture . . . do	7	13	13	----------
Rotation land . . . do	66	60	60	----------
Corn . . . do	22	30	24	----------
Wheat . . . do	11	7.5	12	----------
Oats . . . do	11	7.5	----------	----------
Soy beans . . . do	----------	----------	12	----------
Hay, clover, or mixed . . . do	7	7	----------	----------
Rotation pasture . . . do	15	8	12	----------
Yields per acre:				
Corn . . . bushels	50	50	50	----------
Wheat . . . do	20	20	20	----------
Oats . . . do	45	45	----------	----------
Soy-bean hay . . . tons	----------	----------	1.75	----------
Soy-bean seed . . . bushels	----------	----------	15	----------
Hay, clover, or mixed . . . tons	1.5	1.5	----------	----------

Table 4.—*Standards of organization and management for successful farming on 80-acre farms under three, four, and five year crop rotation systems*—Continued.

		Three-year cropping system.	Four-year cropping system.	Five-year cropping system.	Your own farm.
Crop production:					
Corn	bushels	1,100	1,500	1,200	
Wheat	do	220	150	240	
Oats	do	495	337		
Soy-bean hay	tons			10.5	
Soy-bean seed	bushels			90	
Hay, clover, or mixed	tons	10.5	10.5		
Livestock:					
Work animals	head	3	3	3	
Cows	do	4	4	4	
Heifer, calf	do	1	1	1	
Heifer, yearling	do	1	1	1	
Boar	do	1	1	1	
Sows	do	5	7	6	
Hens	do	100	100	100	
Livestock production per animal:					
Cows, whole milk	pounds	6,000	6,000	6,000	
Cows, butterfat	do	275	275	275	
Cows, calves	head	.75	.75	.75	
Sows, pigs (from weaning to 225 pounds)	do	9	9	9	
Hens, eggs	dozens	10	10	10	
Hens, chicks	head	1.5	1.5	1.5	
Livestock production:					
Cows, whole milk	pounds	24,000	24,000	24,000	
Cows, butterfat	do	1,100	1,100	1,100	
Cows, calves	head	3	3	3	
Sows, pigs (from weaning to 225 pounds)	do	45	63	54	
Hens, eggs	dozens	1,000	1,000	1,000	
Hens, chicks	head	150	150	150	
Approximate feed requirements:					
Work animals (3 head)—					
Corn (43 bushels per head)	bushels	129	129	129	
Oats (25 bushels per head)	do	75	75	75	
Hay (1.2 tons per head)	tons	3.6	3.6	3.6	
Cows (4 head)—					
Corn (20 bushels per head)	bushels	80	80	80	
Oats (18 bushels per head)	do	72	72	72	
Oilmeal (281 pounds, per head) or	pounds	1,125	1,125		
Soy beans (281 pounds per head)				1,125	
Hay (1.5 tons per head)	tons	6	6	6	
Calves and heifers (1 calf, 1 yearling heifer and 2 veal calves)—					
Corn	bushels	14	14	14	
Oats	do	12	12	12	
Oilmeal, cottonseed meal, or soy bean meal	pounds	185	185	185	
Whole milk	cwt	8	8	8	
Skim milk	do	20	20	20	
Hay	tons	1.5	1.5	1.5	
Sows and boar—					
Corn (25 bushels per head)	bushels	150	200	175	
Tankage (100 pounds per head) or	pounds	600	800		
Soy beans (120 pounds per head) and				840	
Mineral mixture (8.5 pounds per head)				60	
Hogs (from weaning to 225 pounds)—					
Corn (15 bushels per head)	bushels	675	945	810	
Tankage	pounds	2,560	3,640	340	
Soy beans				3,250	
Mineral mixture				200	
Skim milk	cwt	12	12	12	
Hens (100 head)—					
Corn	bushels	43	43	43	
Oats	do	38	38	38	
Wheat	do	40	40	40	
Bran	pounds	1,200	1,200	1,200	
Shorts	do	1,200	1,200	1,200	
Skim milk	cwt	120	120	120	
Young chickens, (150 head)—					
Corn (10 bus. per 100 head)	bushels	15	15	15	
Bran (220 lbs. per 100 head)	pounds	330	330	330	
Shorts (220 lbs. per 100 head)	do	330	330	330	
Skim milk (18 cwt. per 100 head)	cwt	27	27	27	
Summary for all stock—					
Corn	bushels	1,100	1,425	1,270	
Oats	do	200	200	200	
Hay	tons	11	11	11	
Oil meal and cottonseed meal	pounds	1,310	1,310		
Soybeans	do			5,400	
Bran	do	1,530	1,530	1,530	
Shorts	do	1,530	1,530	1,530	
Tankage	do	3,160	4,440	340	
Whole milk	cwt	8	8	8	
Skimmilk	do	179	179	179	

TABLE 4.—*Standards of organization and management for successful farming on 80-acre farms under three, four, and five year crop rotation systems*—Continued.

	Three-year cropping system.	Four-year cropping system.	Five-year cropping system.	Your own farm.
Probable products for sale:				
Corn ... bushels		75		
Wheat ... do	200	135	215	
Oats ... do	260	115		
Cows ... head	1	1	1	
Veal calves ... do	2	2	2	
Butter fat ... pounds	960	960	960	
Sows ... head	2	2	2	
Other hogs (225 pounds) ... do	39	57	48	
Hens ... do	30	30	30	
Broilers ... do	50	50	50	
Eggs ... dozens	900	900	900	
Products set aside for family use:				
Orchard, garden, etc ... acres	1	1	1	
Dairy products—butterfat equivalent ... pounds	100	100	100	
Hogs ... head	4	4	4	
Chickens ... do	50	50	50	
Eggs ... dozens	75	75	75	
Wood ... cords	3	3	3	
Items of expense:				
Feed—				
Corn ... bushels			75	
Oats ... do			200	
Oil meal or cottonseed meal ... pounds	1,310	1,310		
Bran ... do	1,530	1,530	1,530	
Shorts ... do	1,530	1,530	1,530	
Tankage ... do	3,160	4,440	340	
Acid phosphate for mineral mixture ... do			100	
Salt ... barrels	1	1	1	
Labor—				
Hired or family ... months	3	3	3	
Fertilizer—				
(200 pounds per acre on wheat) ... pounds	2,200	1,500	2,400	
Seeds—				
Clover (1 bushel to 8 acres) ... bushels	2.75	1.88	1.5	
Timothy (1 bushel to 6 acres) ... do	3.67	2.5	2	
Soybeans (1 bushel to 1 acre) ... do			12	
Vaccination—				
(For hog cholera one treatment of each animal) ... head	51	71	61	
Machine work—				
Threshing wheat ... bushels	220	150	240	
Threshing oats ... do	495	337		
Threshing soybeans ... do			90	
Feed grinding				
Baling				
Repairs—				
House ... per cent of value	1	1	1	
Other buildings ... do	1	1	1	
Fences ... do				
Machinery ... do	2½	2½	2½	
Depreciation—				
House ... do	1½	1½	1½	
Other buildings ... do	2	2	2	
Machinery ... do	9	9	9	
Insurance				
Taxes				
Other expenses				

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1422

UDDER DISEASES *of* DAIRY COWS

A normal udder

THE MAINTENANCE of healthy cows with normal udders is of vital importance to the dairy industry.

A cow that is healthy in every other respect, but has a diseased or nonproducing udder, is worthless in a dairy herd. The prevention and treatment of the diseases which bring about this condition are discussed in this bulletin. The limitations of a bulletin of this kind preclude anything more than a brief discussion of each disease and a suggested line of simple treatment adapted to the means and condition of the average dairyman.

This bulletin is in no sense intended to replace the valuable services of the trained veterinarian, which, if available, should by all means be obtained.

An effort has been made to avoid fine distinctions and technical language in the hope that the information might better supply the widespread need of a practical and popular discussion of the subject.

Washington, D. C. Issued May, 1924

UDDER DISEASES OF DAIRY COWS.

By HUBERT BUNYEA, *Veterinary Inspector, Pathological Division, Bureau of Animal Industry.*

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CHARACTERISTICS OF THE UDDER.

A FUNDAMENTAL AXIOM of horse husbandry is well expressed in the statement "A horse is no better than his four feet." Translated into terms of dairy husbandry, it would sound much like this: "A dairy cow is no better than her udder."

Implied or expressed, this rule largely governs the desirability of animals considered for a dairy herd, or the fitness of any animal to remain in the herd. The attention of the stock judge is focused on the udder conformation as a guide to a cow's excellence, and the dairyman ultimately rates her value to him according to the evidence of the milk sheets and the butterfat test.

The dairy cow's udder is an abnormally developed gland, the result of centuries of careful selective breeding. It is complex in its physiology. Functioning as it does, under high tension, for maximum milk production during most of the adult life of the cow, this marvelous structure is subjected to a very great physical strain, with small opportunity for rest or repair. The extra tax on the udder which is involved in the birth of calves and shortly thereafter often counterbalances the rest allowed between milking periods.

The great development of this organ, as well as its complexity, are factors which render most difficult the treatment of abnormal conditions of the udder of the dairy cow. All things considered, it is usually advisable, when a disease or injury is observed, to undertake treatment only under the advice of a qualified veterinarian.

PREVENTION OF DISEASES AND INJURIES.

Many of the udder conditions which occasion pain and peril to the dairy cow are avoidable. Deviation from regular and established practice in the care of the animal is the frequent forerunner of serious consequences. Lack of care in the use of milking machines, teat dilators, and milking tubes may result in the permanent injury of one or more quarters of the udder. Brier cuts, barbed-wire cuts, and the bruising or crushing of the teats by other cattle stepping on them (often due to bad stall construction), are usually avoidable. These injuries may lead to leaky quarters, fistulous teats, mammitis, and other troubles, with possible loss of function. Udder troubles of cows are sometimes directly or indirectly traceable to brutal treatment by attendants who, in driving the animals to and from pasture, stone them or beat them with sticks, clubs, or whips. Vicious horned animals also inflict injury on their fellows, which may involve the udder as well as other parts of their bodies.

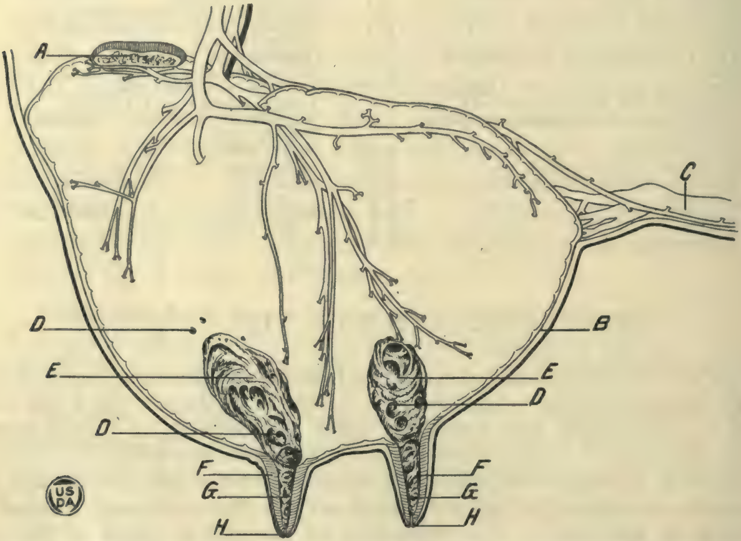

FIG. 1.—Diagram of one-half of the udder of the cow (adapted from H. C. Wilkie). *A*, supramammary lymph gland (in section); *B*, skin; *C*, subcutaneous abdominal vein (milk vein); *D*, openings of the milk ducts, of which there are a very large number opening into the milk cisterns; *E*, milk cisterns; *F*, walls of the teats; *G*, interior of the teats; *H*, orifice or opening of the teat.

DRYING OFF THE COW.

Damage may result from attempting to dry off a cow too suddenly before calving, especially when the animal is on succulent pasture or a rich concentrated ration. In some cows the instinct for milk production is so highly developed that the function seems difficult to repress, even during advanced pregnancy, and efforts to terminate a milking period forcibly in such animals possibly does more harm than good.

To dry off a cow, it is advisable first to regulate her ration. Allow well-cured hay in place of succulent pasture, silage, or beet pulp. By stages eliminate all concentrates, for at this time they tend to excite a congested condition of the udder, as well as to favor the continuance of milk production. Bran may be given alone or with some middlings. For about a week omit every third milking, and then milk once daily for another week, without stripping. Afterwards it may be necessary to milk only a few streams daily to relieve the tenseness of the udder. A few days later, when it is evident that milk secretion has subsided, no further attention will be required, as a rule. This system may be varied to suit individual cases, as some animals may be dried off in less time, while others may require longer.

SEPARATION OF COW AND CALF.

Although there are excellent reasons for the common practice of promptly removing the newborn calf from its dam, it is sometimes advantageous to leave them together. The cow often comes to her milk more naturally and easily with the calf present. The calf discovering its own appetite and then the maternal fount at which it is to be satisfied, begins punching and bunting the udder in a manner well calculated to stimulate the flow of milk and at the same time to "break up" the congestion of the organ. Possibly many a case of mammitis in fresh cows might have been avoided had the calf been left beside its dam until the udder was well "broken up."

VICES.

Some calves acquire the habit of sucking the udders of other calves, a prank which should never be tolerated, despite the apparent harmlessness of it. The possibility of damage is twofold. In the first place it tends to the formation of an ill-shaped and pendulous udder, and hence may seriously detract from the beauty and value of the animal in afterlife. Furthermore, there is the danger that the heifer, especially if of well-bred dairy stock, may become stimulated to a virgin milk secretion. In the course of events this milk secretion, the presence of which is not suspected, may be left to dry up of its own accord, without the necessary care on the part of the owner, with a ruined udder as the possible result. This fact may, indeed, account for many of the cases of hardened udder reported among virgin heifers, since the description of that condition is strongly suggestive of chronic garget of adult cows. To overcome the vice the milk ration of calves may be followed by a handful of grain fed before they are turned out. This tends to remove the desire to nurse.

Cows sometimes acquire the habit of sucking their own teats. While this practice may not harm the cows it is unprofitable for the owner.

There are several more or less effective ways of breaking cows of the habit of sucking their own udders or the udders of other cattle. Some herdsmen have used the common calf weaner (fig. 2*a*), which is a small, biblike attachment for the nose, or the muzzle basket type of calf weaner (fig. 2*b*), either of which contrivances is so arranged as not to interfere with eating or drinking, but which covers the mouth when the head is slightly elevated. Others have resorted to the use of the spiked halter, which is made by perforating the muzzle strap of an ordinary leather halter at intervals of about 1 inch and passing sharpened wire nails through the holes, from within outward, lastly lining the barbed strap to hold the spikes in place. This method, however, borders on the barbarous and may be attended with danger to the wearer or to other stock in the same pasture. A crib, or rigid collar (fig. 3*a*), is more humane, and may be made by lacing together a number of stout sticks in barrel-stave fashion, and tying them around the animal's neck, thus preventing her from bending sidewise and yet permitting her to graze. This apparatus is mainly effective for animals that rob their own udders. Another type of apparatus (fig. 3*b*), which is effective in preventing a cow from robbing her own udder, consists of a halter, to the chin strap of which a stout stick is attached by means of a short chain. The stick is passed between the forelegs and is fastened at the other end by a large metal ring to the lowest point of a girdle fitted comfortably around the animal's body.

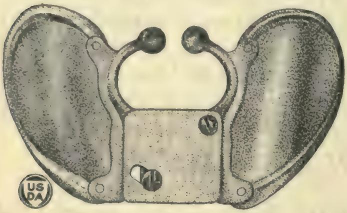
FIG. 2*a*.—A calf weaner. A device on the market for placing in animal's nose.

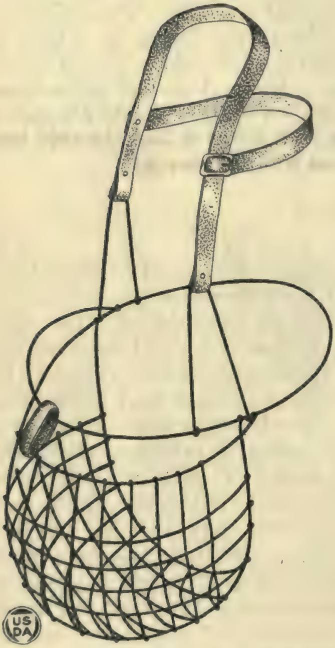
FIG. 2*b*.—Muzzle basket type of calf weaner.

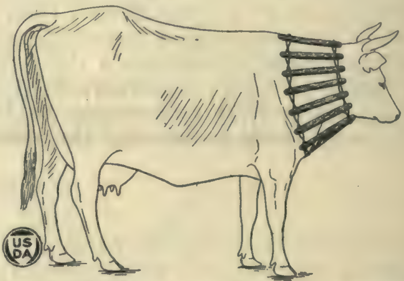
FIG. 3*a*.—A crib, or rigid collar, as applied to prevent a cow from sucking her udder.

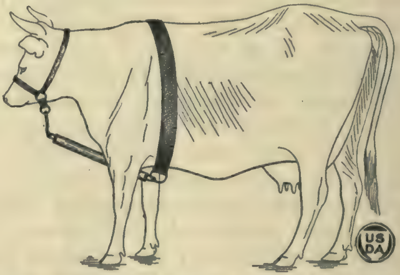
FIG. 3*b*.—Another form of antisucking apparatus.

If mechanical contrivances fail to correct the vice, the culprit may be isolated for a while, or, better still, pastured for a limited time daily under observation or isolation, immediately after milking, and then stanchioned for the rest of the time. After a few weeks of this manner of restraint she should manifest no inclination to return to the habit.

DISEASES AND CONDITIONS AFFECTING THE UDDER.

INFLAMMATION OF THE UDDER (MAMMITIS, MASTITIS, GARGET).

By far the most important disease of the udder is that known as mammitis, mastitis, garget, or inflammation of the udder. The disease assumes three forms, namely, catarrhal, parenchymatous, and interstitial. The first attacks the mucous lining of the udder, the second the milk-secreting structures, and the last the framework of the udder. These differ in some of their characteristics, and in an individual case all may appear at various stages of the disease.

Causes.—Inflammation of the udder may be due to any cause or combination of causes, such as exposure to cold or wet weather, sudden change of temperature, blows, kicks, bruises, or abrasions of the udder, an injudicious allowance of rich feed, the retention of milk, infrequent or irregular milking, the introduction of contaminated instruments into the udder, local infection, indigestion, or any serious disturbance of the animal's health.

The disease sometimes appears in a mild form which soon passes off, to recur at more or less regular intervals. Although the condition usually occurs about calving time there is no part of the milking period in which it may not appear.

Symptoms.—In different forms or stages of the disease there may be a variation in the symptoms. The usual ones are general depression and discomfiture. There is sometimes chill, but it may escape notice. Among the most conspicuous symptoms are a rough coat, dull eyes, loss of appetite, suspended rumination, and possibly constipation. The animal stands in an awkward, straddling position, and moves about or lies down with reluctance and great difficulty, owing to the soreness of the udder, which will usually be found to be hot and tense, very hard, and tender. The fever, though sometimes local, is more likely to be general. A dropsical condition under the skin of the abdomen is sometimes observed.

The secretion of milk is partly or entirely suspended. The milk itself is lumpy or stringy, or its consistency may be altered to that of a serous fluid containing yellowish clots, caused by the coagulation and separation of the casein. The secretion may even become purulent and offensive. Severe inflammation of the udder may also bring about a rupturing of some of the capillaries, which makes the milk bloody.

Recovery may be slow or rapid, complete or incomplete. When the disease passes into a chronic stage there is small likelihood of complete restoration of function. Among the unfavorable results of the chronic condition are hardening of some of the udder tissues, abscess formation, milk fistula, and gangrene of the udder.

Treatment.—Chill, if observed, may be treated by the administration of large quantities of warm drinking water, or of cordial drenches, or by hot bathing, or the use of hot blankets.

To reduce fever, give 1 ounce of spirits of nitrous ether three times daily. A full dose of Epsom salt (1 to 2 pounds) may be given at the onset of the disease, to be followed by daily doses of saltpeter, 1 ounce, and bisulphite of soda, 2 drams, in 1 quart of water, as a drench.

The udder should be completely emptied every two hours if possible, using extreme gentleness in the operation, especially if there are blood tinges in the milk. The presence of blood indicates a rupture of some capillaries. If the udder is very tender, it may be necessary to use a sterile milking tube so as to empty the organ with the least pain.

Twice daily, after milking, the udder should be bathed for about 20 minutes with water as hot as the hand can bear, and meanwhile the attendant should continue gently but firmly to massage the udder in a downward direction. All material brought down into the milk cistern by this manipulation should then be thoroughly stripped out, after which the udder should be dried and anointed with warm camphorated oil or an ointment composed of the fluid extracts of belladonna and phytolacca, 1 part each, and lard or lanolin, 8 parts. An excellent ointment may be prepared after the following formula:

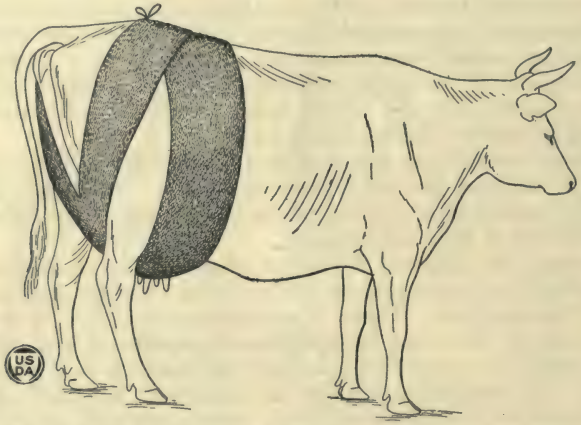

FIG. 4.—Method of applying a suspensory bandage to the udder.

Petrolatum	2 pounds.
Spirits of camphor	2 ounces.
Spirits of turpentine	2 ounces.
Oil of peppermint	½ ounce.
Carbolic acid	½ ounce.
Powdered extract of belladonna leaves	6 ounces.

This is to be mixed thoroughly and applied with massage daily after bathing the udder with warm water. The ointment may be rubbed in thoroughly and the udder should be supported by a dry suspensory bandage having holes cut in the lower part for the teats (fig. 4). The udder may be irrigated daily by means of a sterile milking tube attached to a sterile fountain syringe containing a 1 per cent solution of table salt[1] or a 4 per cent solution of borax, or boric acid, sterilized by boiling and cooled to blood heat. The irrigating fluid may then be milked out with further massage.

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[1] A 1 per cent solution of common salt in boiled water at body temperature makes a suitable irrigating fluid. A heaping tablespoonful of dry salt weighs approximately 1 ounce, and this amount in 1 gallon gives the proper strength.

In infectious mammitis beneficial results have been reported from the administration of one-half ounce of sodium salicylate and 2 drams of boric acid in 1 quart of water morning and night as a drench, and one-half to 1 ounce of formalin in 1 quart of milk or oil at noon for several days. Very frequent milking is also here recommended.

At every stage of the treatment of infectious mammitis a mild but effective antiseptic solution should be applied to the udder and adjacent parts of the affected cow, and also to the hands of the milkers and to the udders of other animals likely to be exposed in any way to the infection.

Affected animals should be separated from the herd, and hand-milked last, or, better, by a separate attendant. They should be maintained under sanitary conditions in dry, comfortable quarters, with frequent change of clean bedding, and other attentions given in the proper care of sick animals. The ration should be regulated so as to include a sufficient allowance of nutritious roughage, such as clover, alfalfa, cowpea hay, and to reduce the concentrate ingredients, such as corn meal, cottonseed meal, linseed meal, gluten, and middlings. Clean drinking water should be accessible at all times and should be slightly warmed in cold weather. A moderate amount of bodily exercise is beneficial provided it is taken voluntarily by the cow. Compulsory exercise may be positively detrimental as well as painful to the animal.

INDURATION, OR HARDENING OF THE UDDER.

Probably the most common of the results of mammitis, or inflammation, is induration, or hardening of the udder. This condition is due to structural changes in the udder tissue. During mammitis the secreting portion of the udder is in a diseased and wasting condition and the inflammation present appears to establish an increase of the connective-tissue cells which go to make up the supporting framework of the organ. The result is likely to be a large, ill-shaped and pendulous udder. In a well-established case of induration the milk secretion is usually very greatly diminished for that period. Sometimes the secretory function is permanently lost, or decreased to such extent that the animal no longer will be profitable in a dairy herd.

Treatment.—Treatment consists mainly in prolonged hot bathing of the udder twice daily after milking, accompanied by gentle rubbing of the parts affected. After drying the udder thoroughly, apply an ointment composed of lanolin or lard into which has been incorporated 2 per cent of iodin.

A rich diet, or one likely to stimulate milk secretion, should be avoided until inflammation has subsided, after which time the animal should be brought by degrees to a full, milk-producing ration. Maintain throughout a rather laxative condition of the bowels by an occasional dose of Epsom salt (about 1 pound).

ABSCESS OF THE UDDER.

Abscess is also one of the possible results of infectious mammitis, and is due to infection of the organ by pus-producing germs. The abscess may work toward the surface of the udder, where it can be assisted to a head and lanced by the veterinarian, or it may be ruptured internally and discharge its creamy, liquid pus through the teat. In the event of both external and internal rupturing of an abscess of the udder, there is danger of establishing a milk fistula.

Treatment.—The abscess may be hastened to a head by hot fomentations or poultices. It is then ready to be opened and drained. The aftertreatment usually consists of simple cleanliness in the general care of the animal and the dressing of the part twice daily with a watery solution containing 5 per cent each of glycerin and phenol.

GANGRENE OF THE UDDER.

Gangrene is caused by a serious interference with the blood circulation, as in some cases where the inflammatory swelling or distention with milk is so great as to produce intense pressure on the blood vessels of this region. The resulting slow, necrotic process causes the death and sloughing off of the affected quarter or quarters. This condition sometimes leads to fatal consequences, due to blood poisoning.

Treatment.—The raw surfaces should be thoroughly and frequently sponged with some good antiseptic, such as a one-half per cent solution of chloride of zinc. If amputation of the gangrenous area becomes necessary, it should be undertaken only by one skilled in surgical procedure.

TUBERCULOSIS OF THE UDDER.

Usually tuberculous infection of the udder may be distinguished from other udder infections by its gradual onset and chronic course, as well as the fact that it rarely occasions the animal any pain or inconvenience. Tuberculosis of the udder usually commences well up in one or both rear quarters, and may involve the lymph glands situated above and back of the two rear quarters of the udder. The organ itself becomes progressively hard and swollen, sometimes acquiring enormous size. Milk secretion appears normal until the infection has progressed considerably, when the milk becomes thin, watery, and scanty, and contains flaky and stringy material, and possibly blood and pus.

This disease, however, may go on unrecognized for years; meanwhile the animal continues to yield milk containing tubercle bacilli, thus endangering the health of other livestock as well as human lives. In case of mammitis that is considered possibly of tuberculous origin, it is advisable to isolate the individual and have the tuberculin test applied at once.

There is no known cure for this disease. In the diagnosis of tuberculosis of the udder no single method is completely satisfactory. The tuberculin test may be relied upon to demonstrate the presence of the disease in the animal, but it is impossible by this means to detect the location of the infection. If a physical examination of the udder corroborates the positive tuberculin reaction, added significance may be attributed to the suspicion of udder tuberculosis. Finally, milk samples from suspected udders may be submitted to a bacteriological laboratory for examination.

Actinomycosis of the udder, caused by the same organism as lumpy jaw, is not so common as tuberculosis, but is sometimes mistaken for it. Definite diagnosis requires a bacteriological examination.

COWPOX.

Cowpox is an acute, contagious disease accompanied by a slight fever and a typical eruption which is usually confined to the teats and udder of the cow. The lesions first appear as small, red papules or nodules, which later resemble blisters and are filled with a clear fluid. The third or pustular stage is marked by the change in the character of this fluid to a puslike appearance and consistency. The fourth stage is that of drying or desiccation of the pustules.

The disease is usually spread by the hands of the milker and may break out on the cow about seven days after exposure. Cowpox is so mild and so lacking in serious consequences that in many herds its presence is either totally ignored or at least is taken for granted. Nevertheless the presence of the sores on the udders and teats renders milking somewhat painful to the cow. To avoid aggravating and prolonging the condition, therefore, the operation of milking should be accomplished with great gentleness, and may be facilitated by the use of the milking tube. The milk should be discarded.

Treatment.—The animal so affected should be isolated and milked last, with usual antiseptic precautions to protect the hands of the milker from the infection. Twice daily the affected area should be bathed with a 3 per cent solution of granular hyposulphite of soda. Once every day or two the pustules may be touched with tincture of iodin or a 5 per cent solution of silver nitrate.

CHAPPED TEATS.

Chapped teats are caused by any irritation, such as sudden chilling after the sucking of the calf, "wet milking" by the attendant, damp or filthy conditions in the stable, wet bedding, overstocking, exposure of tender skin to sun rays in summer, or freezing in winter, etc. The skin is first rough and inclined to scale, and later wrinkles are formed, which become hard and deep and presently break into raw fissures.

Treatment.—Favorable conditions, such as dry quarters and bedding, cleanliness of the udder, and "dry milking," should be assured. Some reliable antiseptic wash may be used, after which the chapped surface should be painted (once daily) with compound tincture of benzoin or a mixture of 1 part of tincture of iodin and 4 parts of glycerin. It may be advisable to anoint the teats with petrolatum before milking, and to use a sterile milking tube so that the milk may be drawn with the least pain to the animal.

WARTS.

Warts on the teats and udder form an annoying disfigurement as well as an obstacle to milking. While perhaps harmless themselves, they may lead to abrasions or fissures, thus exposing the skin of the animal to the invasion of blowflies or infections.

Treatment.—Long warts may be removed by twisting or tying a silk thread tightly about the base of the growth. The wart will eventually slough off.

Repeated applications of glacial acetic acid or other caustic to the body of the wart have been successfully used in the removal of such growths. Care must be observed, however, to restrict this treatment to the objectionable growth, as these chemicals are very injurious to healthy skin. As a precaution, the normal area around each wart may be previously coated with petrolatum or tallow. A safer treatment is to paint the warts with collodion containing 15 per cent of salicylic acid. The collodion film is removed every 3 days and the growth is recoated until it finally sloughs off. The simple application of castor oil at two-day intervals is also said to be effective in killing warts.

Some warts require surgery for their removal. In such cases the aftertreatment consists in painting the wound once or twice daily with tincture of iodin until well healed.

TUMORS.

Tumors in the teat or milk cistern may be harmless growths or simple connective-tissue enlargements due to interstitial mammitis or to a degeneration of the gland accompanying age. As a rule these growths are better not interfered with unless they become so large as to obstruct the milk flow or otherwise inconvenience the cow. Sometimes they may be reduced by the persistent external application of the tincture of iodin or an iodin ointment. If their surgical removal becomes necessary it should be undertaken only by one skilled in the principles of veterinary surgery, and not until the cow has been dried off. Under the most favorable circumstances, surgical treatment of the udder involves the danger of a serious infection of the organ.

Tumors within the body of the udder, and sometimes in the milk cistern, may be tuberculous. Such a suspicion may be dispelled only by the animal's failing to react to the tuberculin test. A tuberculous growth in the udder is beyond remedy and constitutes a real menace to the health of persons and livestock. Seek veterinary advice.

STRICTURE, OR HARD MILKING.

Hard milking is due to an obstruction or stricture, sometimes within the milk duct, but usually at the teat orifice. It may be brought about by a tenseness of the teat orifice, or by scar formation following an injury of the teat.

Treatment.—There are on the market several types of teat dilators, any one of which may be of benefit in correcting this condition. The dilator may be inserted an hour or two before milking, but the instrument should be sterile and the teat thoroughly cleansed before its insertion. After milking, the affected teat should be massaged with petrolatum into which 10 per cent of the fluid extract of belladonna has been incorporated. The alternate use of the ointment and the dilator should be continued until the condition appears to be corrected.

When this treatment fails it may become expedient to resort to surgical measures for the relief of the stricture, but this is done to better advantage after the cow has been dried off, involving a better prospect of prompt healing, and less likelihood of causing a dangerous infection or a leaky teat. The instrument used for this operation is known as a teat bistoury, consisting of a small shaft containing a concealed blade. After the bistoury is thrust well into the teat the blade is uncovered and the instrument is rapidly withdrawn, thus severing the obstructing tissues at one stroke. This procedure is usually repeated three or four times in each teat that is hard to milk, turning the blade in different angles each time. Great care must be exercised to have the instrument sterile for this operation, to avoid introducing infection into the udder. A word of caution to be taken into consideration is that this operation may result in an excessively large teat orifice, and is sometimes productive of the unfortunate condition known as leaky quarter.

ATRESIA (BLIND OR IMPERFORATE TEATS).

Atresia is a defect existing from birth, and is seldom, if ever, discovered until after the heifer has freshened. The owner's suspicion is first aroused when one or more quarters become abnormally large, hot, and painful, while the efforts of the calf to obtain nourishment are evidently unsuccessful. Examination usually reveals the fact that the teat orifice is wanting, but there will be seen clearly a distinct ring surrounding the slight depression where the teat orifice should be.

Treatment.—Treatment is obviously surgical. The orifice may be artificially established by means of a large, sterile needle or a small-bladed knife thrust through the sterilized skin perpendicularly at the center of the depression.

To prevent closure by healing, it is advisable to insert a milk tube, with usual precautions as to sterilization, at milking time, and to replace it between milkings with a sterile teat dilator, or even a strand of antiseptic tape, to act as a seton.

Healing may be promoted by the application of an ointment of the balsam of tolu, or the fluid extract of belladonna and glycerin. Should the opening become sealed during the healing process, it will become necessary to repeat the process already described.

INSECT STINGS.

Cattle are more or less liable to the stings of bees, wasps, or hornets while grazing among clover, alfalfa, or other blossoms. The udder is a frequent point of attack because it is not so well protected by hair as other parts of the body, and, on account of its pendulous position, is more readily accessible to the aroused insect. The sting injects beneath the victim's skin an actively poisonous secretion which is highly irritating and which may eventually prove detrimental to the health and life of the skin. Insect stings, when inflicted in sufficient numbers, have been known to produce a severe, nervous depression, or even the death of the victim.

Treatment.—The injured area should be bathed in a 4 per cent solution of ammonia or a potassium permanganate solution. Internal stimulants may be administered in the form of fluid extract of nux vomica, one-half dram, three times daily.

SNAKE BITES.

The symptoms of snake bites are local swelling and inflammation, suppression of milk, fang wounds, systemic weakness, depression, blue membranes, and later coma or convulsions and possibly death. In the event of survival, abscess formation or sloughing of tissue at the point of injury may develop later.

Treatment.—Thoroughly cleanse the wound with dilute ammonia or a 1 per cent potassium permanganate solution. Endeavor to prevent the absorption of venom by the excision of the wound, cauterizing it, or painting it freely with tincture of iodin. The effect of the toxin on the system should be combated with internal administrations of alcohol, coffee, digitalis, strychnin, or aromatic spirits of ammonia. An antitoxin for the counteraction of snake bites has been placed on the market.

WOUNDS OR CONTUSIONS.

Wounds of the udder may be caused by barbed-wire cuts, brier cuts, nail snags, long and jagged finger nails of milkers, bites of dogs, the trampling of teats under the hoofs of other cattle, high barn doorsills, fence jumping, goring, etc.

Treatment.—Cleanse the wound and keep it clean. If the skin is laid open or the wound is gaping, the underlying tissue should be thoroughly cleansed with an antiseptic solution, the hair should be shaved or clipped from around the injury, and the lips of the wound should be brought together and held in position by means of sutures or strips of adhesive tape. Tincture of iodin should be applied at intervals. In case of pus formation, suitable drainage should be provided, and the wound dressed frequently to prevent the germ-laden discharge from reaching the teat orifices, as such a contingency might involve the infection of one or more quarters, with disastrous consequences.

LEAKY QUARTER AND FISTULA.

When a heavy-milking cow comes up to the barn with milk dripping or streaming from one or more of her distended quarters, the wise keeper realizes that the animal should be milked three or even four times daily instead of twice. Cows of only moderate production may likewise leak milk at times if their milking is long delayed or their capacity of retention is otherwise abnormally taxed. Persistent loss of milk through teat leakage, however, is not only annoying but very unprofitable for the owner.

Chronic leaking is probably due in most cases to weakness of the teat orifice, to a fistula of the teat, or to the effects of a previous operation for the relief of stricture or other teat obstruction.

Weakness of the teat orifice may be overcome sometimes by the local application of tincture of iodin or saturated alum solution twice daily. The common practice of stopping a leaky teat with a rubber band or tape, or inserting a plug between milkings, is inadvisable, as it only tends to aggravate the weakness of the part or to increase the size of the opening. Flexible collodion, into which has been incorporated 1 or 2 per cent of metallic iodin, may be used to seal the teat orifice, twice daily, or immediately after milking.

Teat fistula, due to injuries, constitutes a common and annoying form of teat leakage. Efforts to reduce a teat fistula, however, had better be postponed, if possible, until the milking period of the animal has been terminated. The procedure, which is a surgical one, consists in scarifying the edges of the fistulous opening, bringing the lips together, and suturing them into place to establish a closure of the aperture by healing. This operation should not be attempted by one unfamiliar with the principles of surgery, however, as skill and surgical cleanliness are absolutely necessary, while at the best there always remains the danger of establishing a serious infection of the gland. The aftercare consists in bathing the wound several times daily with a sterile 1 per cent solution of table salt or a mild antiseptic solution.

If a cow in full flow of milk should receive a barbed-wire cut or other injury to the teat which would probably develop into a fistula, the correct procedure would be to suture the wound immediately rather than to await the drying off of the animal and risk the consequences of a leaky quarter. The milking tube under these circumstances should always be inserted before attempting to draw milk from an injured teat.

Rudimentary extra teats should never be removed surgically unless for a compelling reason, as it is a very common source of leaky udders.

BAD FLAVORS AND ODORS OF MILK.

Bad flavors and odors of milk are multitudinous in their nature and origin. Some cases are unquestionably brought about by unsuitable feed in the stall or pasture, others probably result directly from a diseased condition of the gland, while in many cases bad flavors and odors are caused by contaminated milk pails.

Occasionally a cow that is within from one to three months of calving yields milk that imparts a bitter taste when made into butter. Cattle on an impoverished pasture may yield bitter, bad-smelling milk as a result of consuming large quantities of some acrid or pungent weed. An excessively rich stall feeding, if long continued, may in time bring about undesirable flavors in the milk.

In case the milk of all cows in the herd is bad flavored, the probability is that the feed is the cause. If on inspection only a few individual animals are found to be yielding milk that is off in flavor or odor, it is the condition of these animals that is most likely responsible. If, however, the odor and flavor are at first normal, and after the milk has been allowed to stand for awhile become objectionable, the explanation will probably be found in infected milk pails or cans rather than in unsuitable feed or diseased udders.

To overcome such conditions it is first necessary to detect and remove the cause. If due to diseased udders, the animals may be isolated for treatment. If due to errors in feeding, the errors must be rectified. If due to bacterial contamination, it must be prevented by the thorough sterilization of receptacles, and other measures of sanitation in the routine operation of milking.

BLOODY MILK.

Bloody milk is a symptom of any of the following conditions: Mammitis, injury to the udder, hardening or induration, tuberculous infection of the udder, the eating of acrid or irritant feed, or an excessive allowance of protein feed. The operation of milking also may aggravate a tendency to hemorrhage if the udder is injured or inflamed.

Treatment consists in determining the cause, if possible, and in applying the remedial measures found elsewhere in this bulletin. The application of the following general treatment may be sufficient to afford relief in mild cases:

Completely milk out the udder at least four times daily, at regular intervals; bathe the udder with cold water, then dry and apply camphorated oil to the quarter with gentle massage; avoid an excessively rich diet; encourage the animal to utilize as bulky a ration as is consistent with her milk production; administer an occasional dose of Epsom salt (about 1 pound) as needed, also a half ounce of saltpeter once daily. Should the hemorrhage persist, inject several ounces of a sterile 2 per cent tannic acid solution at blood heat into the affected quarter by means of a milking tube attached to a fountain syringe.

Redness of milk which does not appear until several hours after milking is probably due to contamination of the milk with some one of the chromogenic (color-producing) organisms.

ROPY MILK.

Milk sometimes is ropy, stringy, or slimy. The cause may be in some irritant forage to which the cattle have access, or other error of feeding, or the condition may be of bacterial origin.

Treatment.—Affected animals should be stall-fed on a properly balanced ration, or pastured on an abundant, suitable growth in a well-drained meadow. Each animal may receive a daily drench of Epsom salt, 2 ounces, and bisulphite of soda, 2 drams, in 1 quart of water.

If the unnatural condition is found to be acquired after the milk is drawn, it is probably due to lack of cleanliness at some stage of the handling of the milk. In this event, efforts should be directed toward the disinfection of utensils, and other sanitary measures.

The prompt pasteurization of new milk at a temperature of 140° F. for 30 minutes should protect it from becoming viscous or assuming other undesirable properties ordinarily attributable to bacterial action.

MILK STONE, OR CALCULUS.

Milk stone, or calculus, is a term loosely applied to concretions in the udder. Some stones are formed by coagulated casein and may be an indirect result of udder inflammation, while others are simply accumulations of lime salts from the milk, which sometimes may be distinguished by the occasional discovery of gritty particles in the bottom of the milk pail or on the strainer cloth.

Treatment.—After a prolonged, gentle massaging of the teat extremity with an ointment containing 10 per cent of the fluid extract of belladonna leaves, the concretions, if not very large, may be passed with the aid of a sterile spring teat dilator. The injection of a small quantity of sterile olive oil into the teat may assist materially in the removal of the obstructions. In case the stones can not be removed in this way it may be necessary to remove them by means of an opening in the side of the teat. This operation should not be undertaken by the inexperienced layman, as the danger of seriously infecting the udder by insanitary procedure can not be overestimated, as well as the extreme likelihood of leaving a fistulous, leaky teat. Unless the concretions are sufficiently large to constitute an obstruction, their surgical removal, even by a veterinary surgeon, had far better be postponed until the cow has been dried off.

AGALACTIA, OR SUPPRESSION OF MILK.

The disease known as agalactia, or suppression of milk, is not infectious in cattle, as it is in sheep and goats. Neither is it so common. Occurring, as it usually does, at calving time, agalactia seems to be unfavorably influenced by such predisposing causes as indigestion, loss of appetite, mammitis, insufficient or unsuitable feed, plant poisoning, severe insect stings on the udder, thirst, enforced driving, fear or excitement, or the removal of the calf. Incidentally, agalactia is a reliable symptom seen in rabies in the cow.

Treatment.—The animal, if a heifer, should first be examined for the possibility of atresia, or imperforation, of the teats. Eliminating this possibility, the attention should be directed toward determining, if possible, the contributing cause or causes, which should receive prompt attention.

The animal should be surrounded with an environment most conducive to her comfort and complete satisfaction. She should be supplied with an abundance of fresh, clean, drinking water, and have a generous allowance of a ration, preferably in the form of a warm mash, calculated to stimulate milk secretion. Milk secretion may be assisted by the repeated administration of strychnin, one-half grain, and pilocarpin, 1 grain, in water at five-hour intervals, until six doses have been given. Massaging the udder with lard or an ointment containing extract of belladonna leaves may assist in bringing her to her milk. Efforts should be made to milk her twice daily, at regular milking time, even though the efforts are unrewarded. If the calf is brought to her side shortly before milking time, this additional appeal to her maternal instinct may have the desired effect.

MILK FEVER, PUERPERAL FEVER, OR PARTURIENT APOPLEXY.[2]

Milk fever sometimes follows calving in fleshy or heavy-milking dairy cows. It is characterized by its sudden appearance and its acute course. The animal becomes paralyzed and passes into a semiconscious or unconscious condition, which may terminate in death. The cause of the disease is unknown, but that it is predisposed by such causes as a highly developed milk production, an excessively nourished condition, and lack of exercise, is beyond question.

The symptoms of milk fever are characteristic and easily recognized. Soon after calving, the cow may exhibit signs of excitement and anxiety, after which constipation and colicky symptoms may be manifest. The owner may notice a staggering gait and weakness, especially of the hind quarters. Eventually the cow, no longer able to maintain the standing position, goes down and assumes the posture so characteristic of this disease (fig. 5), with the hind legs extended forward and the head thrown back toward the flank. A comatose condition may ensue, during which there is danger in attempting to administer medicine by the mouth, as the throat muscles are temporarily paralyzed and the material may pass into the windpipe and lungs. Pulse and respiration are weak and the temperature is more frequently subnormal than otherwise. Death or recovery will occur within two or three days, or even less.

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[2] A fuller discussion of this disease is contained in Farmers' Bulletin 206, "Milk Fever, Its Simple and Successful Treatment," copies of which may be obtained from the Office of Publications, United States Department of Agriculture.

Prevention may be favored by the following measures. When the cow is dried off prior to calving she should be placed on a light ration of bran and a little oatmeal, supplemented with suitable hay and possibly some succulent roots or an occasional feed of silage or beet pulp. She should be housed in a dry, comfortable, well-ventilated stable, amid sanitary surroundings, properly bedded, and given sufficient and regular exercise daily up to the time of calving. Several days prior to calving she should receive a full dose of Epsom salt.

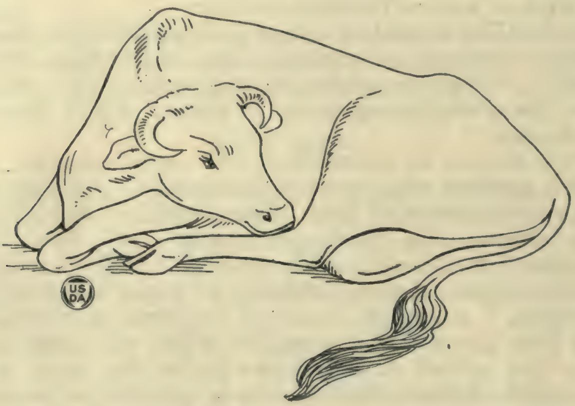
FIG. 5.—Characteristic attitude of a cow with milk fever.

Treatment.—This consists in the inflation of the quarters of the udder with sterile air and tying the teats with broad tapes until several hours after the animal regains its feet. The operation must be performed with the utmost regard for cleanliness. A clean cloth should be laid beneath the udder, which is then washed clean and sterilized with 5 per cent carbolic-acid solution.

The apparatus (fig. 6) consists of a rubber-bellows arrangement attached to a rubber tubing, which in turn is connected with a hollow-metal cylinder containing sterile cotton for the filtration of the air. Another rubber tube is attached to the other extremity of the metal cylinder, and at the other end of the rubber tube is the metal teat catheter. The last tube and metal catheter should be thoroughly sterilized by boiling and the hollow-metal cylinder should be loosely packed with sterile cotton.

The catheter is then inserted into one of the teats of the previously disinfected udder, and the rubber bulb is operated by repeated compressions until the quarter is well inflated. Massage of the quarter during inflation will assist in filling the recesses of the gland with the sterile air. The catheter is then withdrawn and the teat tied with broad tape. After the inflation of all four of the quarters the veterinarian will have opportunity to attend to any complications which may have arisen, or to administer hypodermic doses of strychnin, caffein, or other stimulants which may be indicated. Medicinal treatment is usually superfluous, however, in uncomplicated cases of milk fever. Following the sterile-air treatment alone, it is no uncommon experience to find the cow on her feet from 30 to 60 minutes later, eating hay as though there had never been the slightest disturbance of her normal condition.

Should the first treatment fail to give relief, the procedure should be repeated, as the air previously injected may have escaped or become absorbed. Following recovery, the tapes may be removed in about 5 hours. The air should remain in the udder for 24 hours, after which time it should be completely extracted by the manipulation used in milking. It is then safe to permit the calf to suck.

The milk-fever apparatus described above may now be obtained from many sources, as, for instance, dairy-supply houses and mail-order concerns. Every herd owner should possess such an outfit as a matter of insurance.

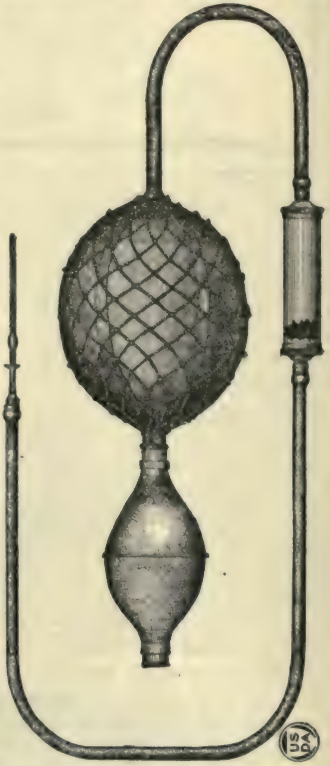

FIG. 6.—Apparatus, used in treatment of milk fever, for injecting sterile air into the udder.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

February 12, 1924.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1423

PREPARATION OF CABBAGE FOR MARKET

THE DEVELOPMENT within the past few decades of large cabbage-producing sections in the Southern and Western States, in addition to the increased acreage in the old-established areas in the northern districts, has increased materially the market supplies of cabbage. Consequently, growers and shippers have found it necessary to give closer attention to the marketing of this crop.

The purpose of this bulletin is to discuss the operations involved in preparing cabbage for market, and to recommend various methods that have proven satisfactory.

Washington, D. C. Issued July, 1924

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PREPARATION OF CABBAGE FOR MARKET.[1]

Charles W. Hauck, *Investigator in Marketing Fruits and Vegetables, Bureau of Agricultural Economics.*

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MARKET TYPES OF CABBAGE.

CABBAGE may be classified commercially into five distinct types: Danish, domestic, pointed, red, and savoy. This classification is based entirely upon terms adopted by the trade and has no direct connection with horticultural varieties or the regions where grown. The first three types have the greatest commercial importance.

The term Danish or Hollander is commonly applied to the solid-headed, late-maturing cabbage, which is generally used for storage and late-marketing purposes. Heads of this type usually have the leaves closely compacted and overlapping at the crown. They are comparatively smooth and solid around the base between the midribs of the leaves, even after successive head leaves have been stripped off. The heads are usually round or oval, but at times are somewhat flattened. The outline of the head as seen from above is smooth and regular. The midribs of the outer leaves generally extend outward and upward at an angle from the stalk, so that the base of the head appears rounded or elongated.

Domestic cabbage is usually not as compact as Danish, but the heads are reasonably hard. They are flat or round, and when the crown leaf is removed the head appears somewhat angular in outline. The leaves are usually crinkled or curled and do not overlap so far at the crown as in Danish cabbage. The head is usually somewhat soft at the base between the midribs of the leaves. The leaves tend to form a right angle with the stalk or they even droop or curve downward slightly before curling upward to form and envelop the head, thus giving the base of the head a flattened appearance.

The shape of the heads, particularly those of Danish type, is subject to considerable variation, dependent upon soil, climatic, or cultural conditions, so that at times it is difficult to distinguish heads

---

[1] For a more complete discussion of the marketing of cabbage see Department Bulletin No. 1242: Marketing Cabbage, by A. E. Cance and G. B. Fiske. Copies may be secured from the United States Department of Agriculture, Washington, D. C.

91205°—24

of Danish cabbage from those of domestic type when judged by the shape alone. The most accurate method of differentiation under these conditions is to base the identification largely upon the characteristics displayed by a vertical cross section through the center of the head. The typical characters of these two types of cabbage are shown in Figures 1, 2, 3, and 4.

Early maturing varieties of domestic are grown almost entirely for marketing as fresh cabbage. Late summer or fall varieties are grown both for market and sauerkraut purposes. Both Danish and domestic types are grown extensively in the North and West, and domestic is produced to some extent in the Southwest.

The pointed type is readily recognized by the conical or pointed shape of the head, together with the comparatively smooth surface and greenish color of the leaves. The pointed type makes up the largest proportion of the acreage in the southeastern districts, and is grown to some extent in a few of the Western States. The two most important varieties of this type are illustrated in Figures 5 and 6.

The red type is known by its red or purple color. Heads of the dark red or purple varieties are as hard as Danish cabbage, but the lighter red varieties are only fairly hard, or in this respect are comparable to the domestic round type. Red cabbage is grown to a limited degree in New York and Wisconsin and is used principally for pickling and salad.

The savoy type is grown only in small quantities. The normal crumpling or blistering of the leaf tissue throughout the leaves and head make it readily identified. The heads are of a yellowish-green color and as a rule are not much more compactly formed than head lettuce, although some varieties are reasonably hard. It is a fairly important crop near New York City and on Long Island.

TIME AND METHODS OF HARVESTING.

In the northern sections the solidity of the head is the usual characteristic by which the proper state to harvest is determined, although with some varieties the color is also a factor, the crown or top of the head turning a lighter shade of green about the time of full development. Cabbage is usually considered ready to cut when the green cover leaves begin to curl back slightly, exposing the whiter leaves beneath. Cabbage at this stage is about as hard and heavy as it will become without bursting and without being too crisp and brittle for good handling.

Cabbage grown as a truck crop frequently is harvested as soon as it has attained sufficient size to be placed upon the market, regardless of its stage of maturity. Growers, especially in southern areas, often harvest the heads while they are still soft, in order to secure higher prices at the beginning of the season, but in most cases this results in a considerable loss in tonnage. Moreover, the quality of the product is inferior. Shipment of such stock has the effect of weakening the market and incidentally limiting demand, since it causes the consumer to curtail his purchases. Stock cut when soft or immature wilts badly, and when displayed for sale presents an unattractive appearance. On the other hand, cabbage that is not harvested soon enough becomes overripe and necessitates close trim-

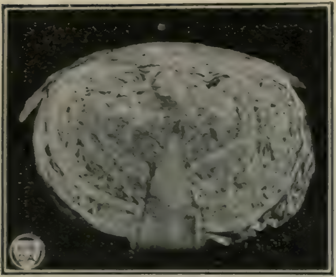

FIG. 1.—Cross section of typical head of Danish or Hollander cabbage. Leaves are very compact. The leaf midribs extend outward and upward from the stem. In the flatter types of Danish or Hollander this is not so pronounced.

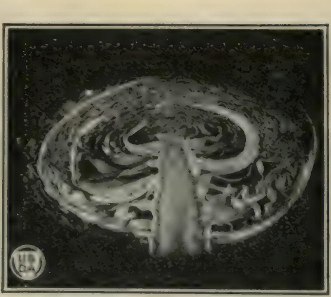

FIG. 2.—Cross section of typical head of domestic cabbage. The leaves are not so compactly formed as in Danish. The leaf midribs form a right angle with the stem or curve downward slightly.

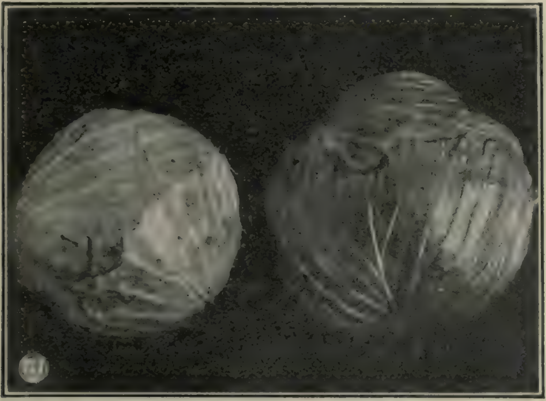

FIG. 3.—Danish cabbage (left) is smoothly circular in outline as viewed from above. Domestic cabbage (right) is somewhat angular in outline.

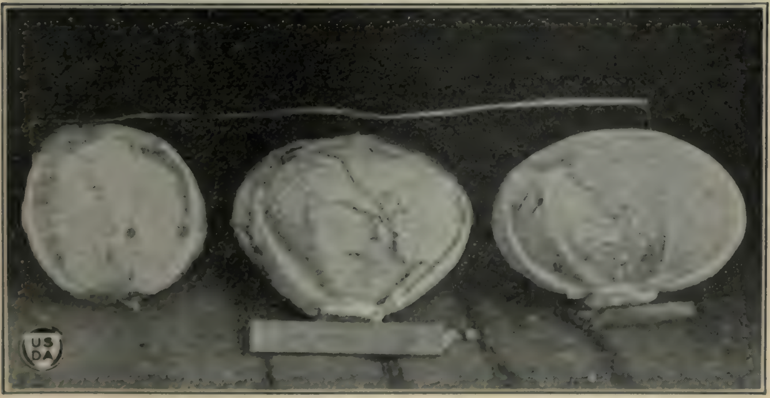

FIG. 4.—Three heads of Danish or Hollander cabbage, illustrating the typical round, balloon, and oval shapes.

ming. Such heads have a white appearance and are very tender. They are too brittle for long shipment.

The common practice throughout the northern cabbage sections is to allow the crop to stand until all of it can be harvested at one or two cuttings. Throughout the South and those sections supplying the midseason market, two or more cuttings are necessary, because in these districts the ripening often extends over a long period.

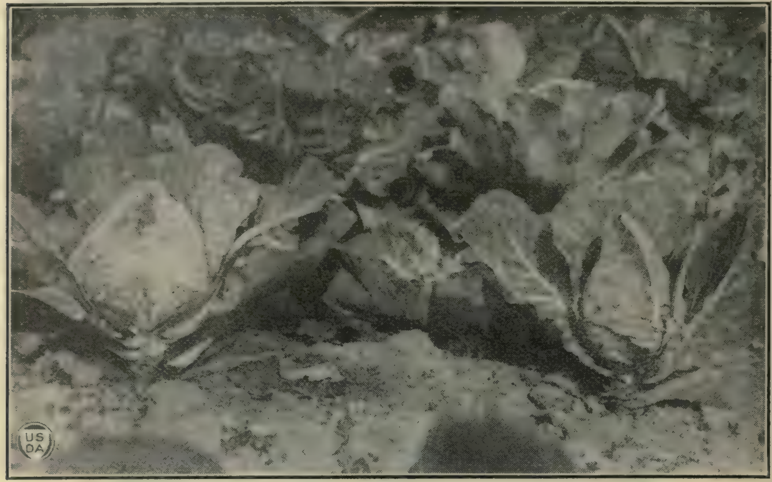

FIG. 5.—The short, squatty head on the left is Charleston Wakefield. The abruptly pointed head on the right is Jersey Wakefield.

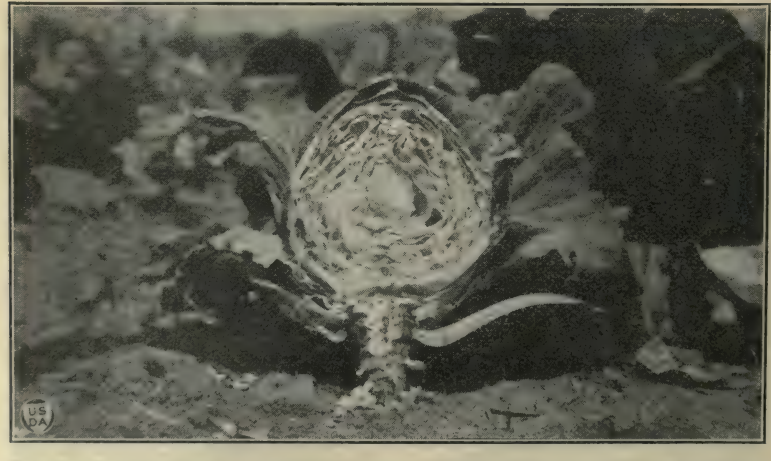

FIG. 6.—Cross section of head of Charleston Wakefield cabbage. The air spaces between the leaves are typical of pointed cabbage.

In the northern districts, harvesting of Danish or Hollander cabbage often continues until the middle of November, in which event freezing temperatures may occur before the harvesting is completed. The outer leaves which show evidence of freezing injury are trimmed off before loading. In case the freezing extends into the head, cutting should be discontinued for a time. If favorable weather follows, the heads will thaw, and may show no evidence of injury when the outer leaves are trimmed off.

The most common method of harvesting is to sever the head from the stem with a large butcher knife. (Fig. 7.) Some growers use hatchets, long-handled spades, tobacco shears, or knives of various descriptions, commonly patterned after the semicircular chopping knife or meat cleaver. In some sections a long-handled, spade-like knife, known locally as a "spud," is a popular harvesting tool.

Cutting tools with long handles permit the harvesting to be done with comparative ease and rapidity, but are not conducive to careful work, as many of the heads are cut either with too long a stem or with part of the base chopped off. The use of a heavy knife is more satisfactory. . Heads with deep slices cut off at the stem end, and with the loose outer leaves falling readily from the heads as a result of such practice, detract materially from the good appearance of a carload, to say nothing of the increased likelihood of decay.

Cabbage intended for immediate shipment should be trimmed to two to four close-fitting wrapper leaves, as shown in the center in Figure 8. Any leaves showing material damage from worms, disease, or other means should be removed, even though it necessitates close trimming. The green outer leaves serve to protect the heads and may be removed at destination if necessary to give the lot a fresh appearance. Stems should be one-quarter to one-half inch in length.

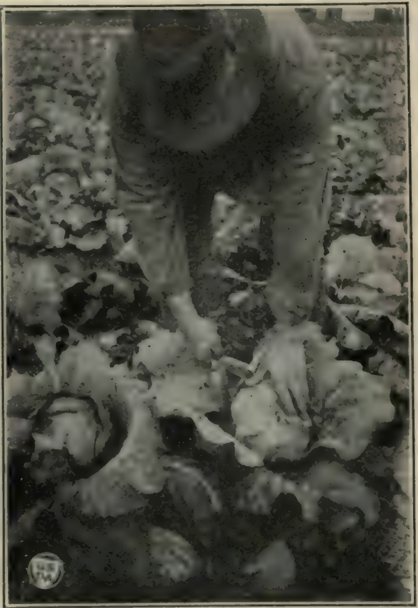
FIG. 7.—Common method of harvesting is to sever the head from the stem with a large butcher knife.

In harvesting late-crop cabbage the usual procedure is to cut and trim the heads at one operation, rolling several rows into one. When loading these trimmed heads into the wagon a reasonable amount of care should be exercised in order to prevent bruising. Bruised tissues become watery in appearance and later turn dark, often followed by decay. The heads should not be allowed to fall into the wagon bed, but should be tossed to an extra man on the wagon and placed carefully on the load.

In southern sections, where it is customary to ship cabbage in hampers or crates, the containers are often packed in the field as the heads are cut. In the Carolinas and Virginia it is customary to throw the heads into carts which are driven ahead of the cutters.

Each man follows two or three rows and cuts the heads that are sufficiently developed. The carts are unloaded at some convenient place, where the cabbage is graded and packed into the containers.

NECESSITY OF CAREFUL GRADING.

Care should be exercised in the handling of cabbage, whether it is to be shipped in containers or in bulk. The attractiveness of a neatly trimmed, carefully graded lot of cabbage more than pays for the extra time and attention required in its preparation.

No one factor is more important in marketing fruits and vegetables than careful grading. High standards, consistently adhered to, build good will and create confidence. Definite grades are coming into general use in many sections in preparing cabbage for market. It is recognized increasingly by growers and shippers that fresh, sound, firm cabbage brings higher returns than soft, puffy, leafy, or worm-eaten heads, and that it pays well to discard such defective heads before shipping. They should be left in the field at time of cutting. The arrival on the markets of large quantities of cabbage that is poorly graded or in bad condition quickly depresses the demand, while, on the other hand, deliveries of uniformly good quality stimulate increased consumption.

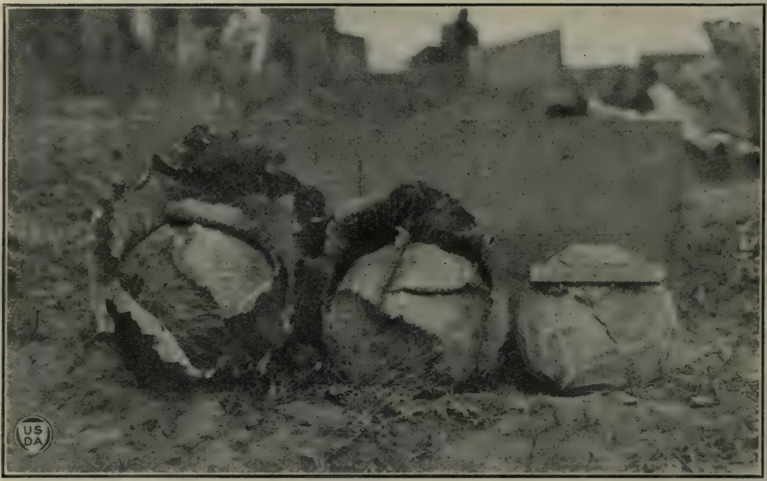

FIG. 8.—Head on left is poorly trimmed, one in center is well trimmed, and one on right is closely trimmed.

When cabbage is loaded in bulk, small, puffy, burst, worm-eaten, or otherwise defective heads, as shown in Figure 9, may be returned to the wagon along with the loose leaves that have been trimmed off or that have shattered off in handling. A slight amount of retrimming at time of loading is sometimes necessary.

Small or medium-weight cabbage is the most desirable market size. Heads of pointed cabbage weighing 1 to 4 pounds and heads of Danish and domestic cabbage weighing 2 to 6 pounds are preferred by receivers. When loading in bulk, a certain amount of sizing can be done at the car, as most shippers in the Northern States instruct their loaders to reject all heads estimated to weigh less than 2 pounds. Heads weighing more than 8 pounds are undesirable.

Extreme irregularity in size should be avoided. Shipments from northern sections often are especially selected for size, grading "small," "medium," or "small to medium." In some cases, where the field run shows a considerable number of large heads, the largest are hauled separately. Shippers frequently load out straight cars from one field, a practice which often results in a more uniform grade and size than if the car were loaded from several fields without grading.

In districts where cabbage is packed in containers for shipment, whatever grading and sizing is done must occur, of course, before the heads are packed. The packer can do a certain amount of grading, although this discarding of defective stock can be done at less expense in the field.

When cabbage is shipped in containers it is particularly important to pack large heads separately from small and medium heads, rather than to place all sizes in the same package. In some sections, notably the southern Ohio district, it is customary to size the cabbage in this way before packing, with the result that the crop finds a more ready market and brings increased returns. The retail trade prefers fairly uniform sizes because it is easier to set a price on each head and because uniform sizes permit the selection of crates containing the sizes wanted. The premium paid for the medium sizes usually more than offsets any discount on the very small and very large heads and pays well for the slight increase in the time required in the sorting and packing operations.

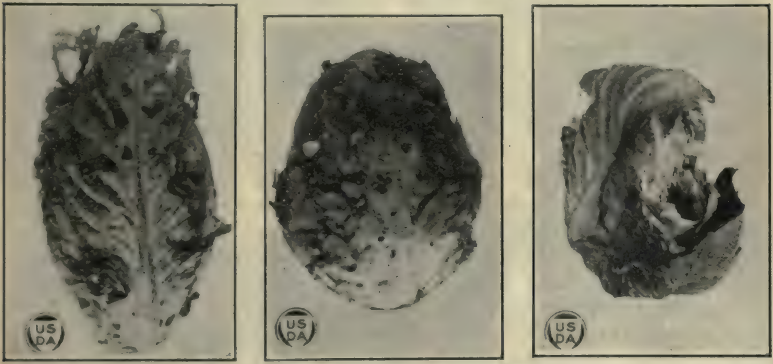

FIG. 9.—Burst heads and heads showing slime or bad worm injury should be discarded.

The Department of Agriculture has prepared standard specifications for cabbage which provide for two grades, U. S. No. 1 and U. S. No. 2. The difference between the two grades relates to market quality rather than to size, the size being stated in addition to the grade. These standards provide that heads of cabbage which meet the quality requirements of the U. S. No. 1 grade may be designated as U. S. No. 1 Small, U. S. No. 1 Small to Medium,

U. S. No. 1 Medium, U. S. No. 1 Medium to Large, or U. S. No. 1 Large, depending upon the weight of the heads.[2]

These standards furnish a common terminology that may be used in describing a given shipment of cabbage, and provide a basis for contracts, sales, inspections, adjustments, etc. It may readily be seen that if a lot of cabbage is described as U. S. No. 1 Medium, a clear and definite understanding of both the quality and size of the cabbage comprising the shipment may be had by both buyer and seller without actually seeing the lot. The intelligent use of standardized grades not only minimizes the possibilities for misunderstanding but also for fraud, deception, and sharp practice. Several important cabbage-producing States have adopted the Federal cabbage standards as official State standards, using them as the basis for official inspections.

GOOD CONTAINERS HELP TO SELL.

Shipments originating in the early producing States and in some of the mid-season sections are made extensively in containers. These are of several different types and of a great variety of sizes and dimensions. In general, the crate is the most popular shipping package, although barrels, hampers, and even sacks are used to some extent.

Hampers and barrels are rapidly being replaced by crates. The principal objections to these containers are that they are not as sturdy as the crate, their shape makes them more difficult to load than a rectangular package, they do not allow sufficient ventilation of the contents, and they do not permit the cabbage to be displayed as effectively. Furthermore, they lend themselves readily to deceptive packing. The nature of these packages is such as to encourage the tendency of some packers to conceal small or defective heads in the bottom or center of the container.

Throughout the United States more than 24 different sizes or styles of cabbage crates are in use. In Tennessee, a pony crate, holding approximately 60 pounds, is used. One of about 80 pounds net weight is frequently used for the shipment of California cabbage to eastern markets. In other sections crates holding 140 and even 180 pounds are used. The crate most commonly employed holds about 100 pounds and has approximately the same volume as a standard barrel, but even with a crate of this capacity the dimensions are extremely variable.

The confusion resulting from this large variety of crates is great, and the need for some reduction in the number is apparent. It is hoped that eventually the various cabbage crates may be standardized into four types which will fit the requirements of all sections and at the same time do away with the extensive variety of sizes and dimensions. The four recommended types are illustrated in Figures 10 to 13, inclusive. Their dimensions and capacities are as follows:

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[2] The Federal grades for cabbage may be subject to further revision and therefore are not given here. Copies may be secured from the Bureau of Agricultural Economics, Department of Agriculture, Washington, D. C.

Type.	Inside dimensions (inches).	Length of slat (inches).	Capacity (cubic inches).
Atlantic coast	12 by 18 by 33	36	7,128
Mississippi Valley	16 by 16 by 28	30	7,168
Colorado	21 by 22 by 24	24	11,088
California	18 by 18 by 23¾	24½	7,695

These are all single-compartment crates with the exception of the Atlantic coast type, which is equipped with a center head, dividing the crate into two compartments.

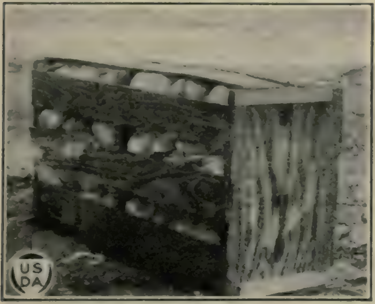

FIG. 10.—Atlantic coast type of cabbage crate.

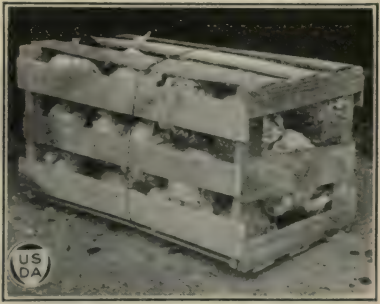

FIG. 11.—Mississippi valley type of cabbage crate.

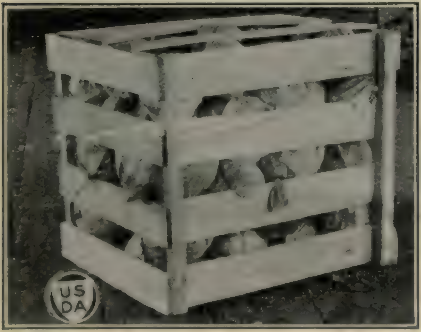

FIG. 12.—Colorado type of cabbage crate.

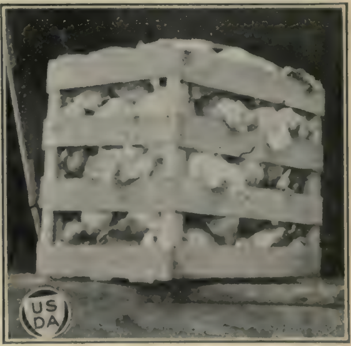

FIG. 13.—California type of cabbage crate.

Cabbage crates should be neatly and securely constructed of substantial material. Flimsy or damaged containers present a poor appearance and often give rise to extra handling and renailing after arrival in the markets.

The heads should be placed in the crate with the stems out, and should be arranged in orderly layers. They should be pressed firmly but carefully into position so as to make a tight pack. Crushing and excessive bruising should be avoided. The crate should be well-filled so that the cover slats will show a slight bulge, thus preventing damage from shifting of the contents during handling and in transit.

METHODS OF LOADING CARS.

Some shipments from southern points and most of the early fall shipments from the North are made in stock cars or in box cars, but when shipments are expected to encounter extremes of temperature refrigerator cars are used if available. In mild weather the doors of box and stock cars are fastened open, and the doorways slatted across to hold the stock in place, but when freezing weather approaches the doors are closed, the cars are lined with paper, and the load is embedded in a layer of straw. Occasionally provision is made for heating the car. Bulk shipments are usually loaded 3 to 5 feet deep throughout the entire length of the car, and consist of 12 to 14 tons. In winter the cars are frequently bulkheaded and braced between the doors with no cabbage loaded in the doorway. This reduces the likelihood of freezing injury and also facilitates the handling of the stock in the car when received in the market.

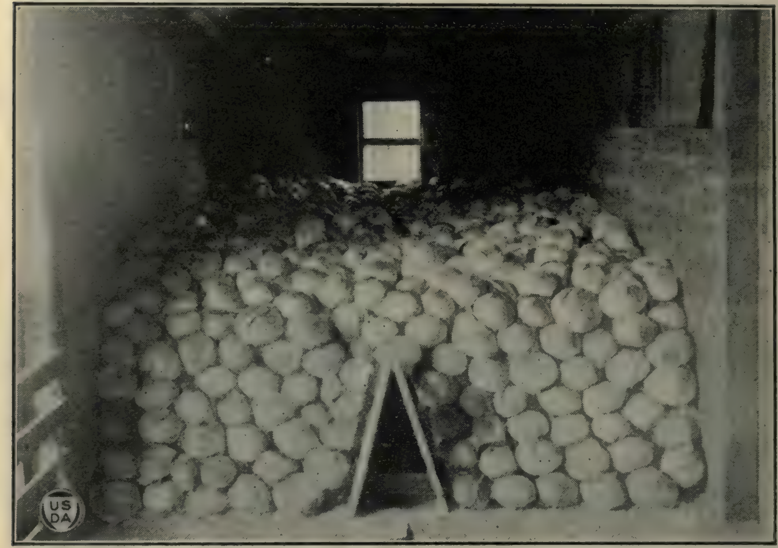

FIG. 14.—A ventilating frame permits free circulation of air throughout the bulk load.

Thorough ventilation is essential. In refrigerator cars slatted false floors should be used. For early fall shipments from the Northern States and for bulk shipments from Texas, shippers usually place an A-shaped, slatted ventilator shaft throughout the entire length of the car. These ventilators are constructed along the floor in the center of the car before loading. There is little uniformity in their dimensions, but the most common type is 2½ to 3 feet high and about 1½ to 2 feet across the base. (Fig. 14.) In loading cars thus equipped, it is advisable to leave about 2 or 3 feet of the frame open at the top between the doorways to permit the free circulation of air in the car, thereby reducing the possibility of the top of the load becoming discolored during transit.

A common method of loading cars for bulk shipment is to place each head individually as it is received from the wagon, carrying the cabbage back from the door in baskets or crates. This generally requires two men in the car, but serves the very useful purposes of preventing bruising and making the carload appear to good advantage. The load is usually built up in successive benches 3 to 5 feet in width, extending across the car. The heads are carefully arranged with stems down in such a way as to form a smooth slanting face to each bench. Cars loaded carefully in this way are neat and attractive. In some cases only the heads forming the front of the bench are placed individually, the remainder of the bench being built up without regard to the position of the heads. The practice of loading by tossing the heads indiscriminately into the car causes much bruising and mechanical injury, and thus increases the possibility of the development of decay in transit. Cars loaded in such a way are unattractive in appearance.

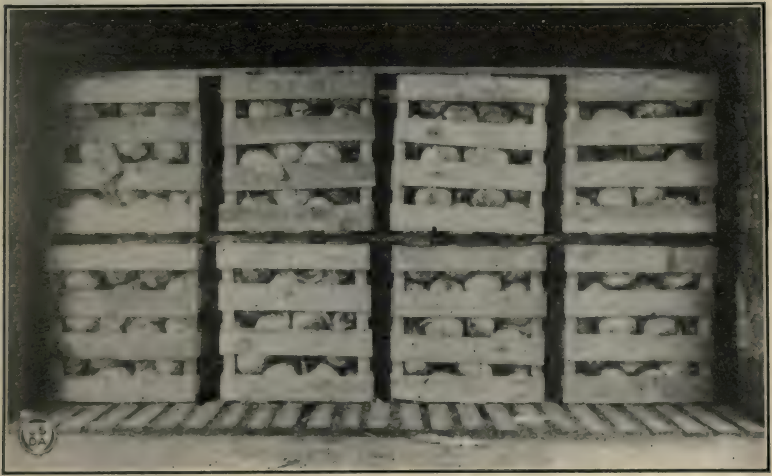

FIG. 15.—Crates loaded in a car should be evenly spaced and securely stripped.

When loading crated cabbage, a space of 2 inches or more should be left between the rows of packages, each layer of crates being stripped crosswise of the car with 1-inch strips (or plaster laths doubled), securely nailed to the tops of the crates. This spacing is essential in order to permit free circulation of air throughout the load. The load should be firmly constructed so that no shifting or breakage may occur in transit. (Fig. 15.)

A common mistake in loading hampers is to place them on their sides five or six layers high. As a result the containers in the bottom of the load usually become crushed in transit, as shown in Figure 16. If loaded on end, two or three layers high, with tops and bottoms alternating, these packages will carry fairly well.

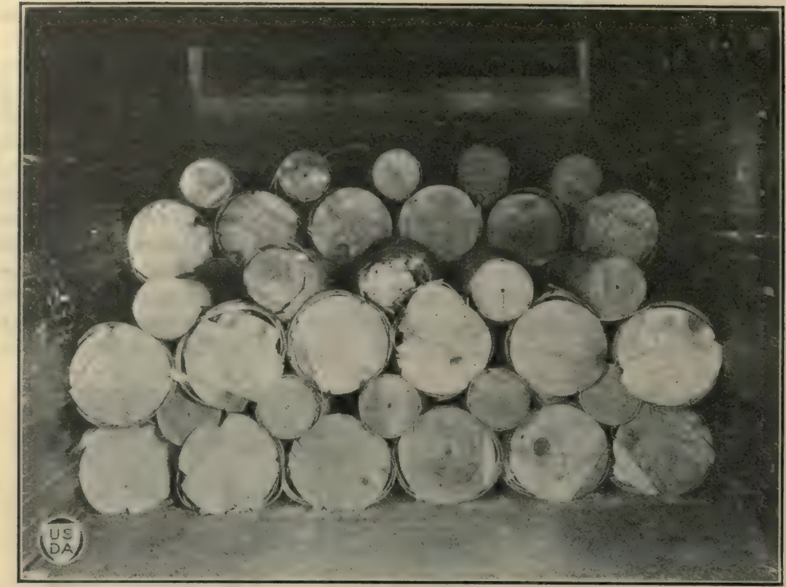

FIG. 16.—Damage frequently occurs in transit when hampers are loaded on the sides.

The following table indicates the number of packages per car:

Containers.	Number packages per car. (Range).	Usual number of packages per car. (Approximate).
Barrels, 100 to 110 pounds	200 to 250	200
Crates:		
Atlantic coast type, 100 to 125 pounds	200 to 220	210
Mississippi Valley type, 100 to 125 pounds	200 to 220	210
Colorado type, 140 to 175 pounds	160 to 180	
California type, 105 to 125 pounds	180 to 210	200
Texas type, 150 to 200 pounds	132 to 175	150
Pony type, 60 pounds		400
Hampers, 1½ bushels, approximately 50 pounds	425 to 550	450

HANDLING CABBAGE FOR SAUERKRAUT MANUFACTURE.

The sauerkraut industry is confined almost exclusively to producing States in the North. In general, only domestic type cabbage is used for sauerkraut, although at times a portion of the Danish crop is consumed in this way. Extremely large heads of Danish are frequently diverted to the sauerkraut factories. Large, well-matured, closely trimmed heads are preferred by the manufacturer. As a rule, little care is exercised in handling cabbage intended for immediate use by factories.

METHODS OF STORING CABBAGE.[3]

Only Danish or Hollander cabbage can be stored without excessive shrinkage and the bulk of the tonnage used for this purpose is grown in New York and Wisconsin. Houses in which cabbage is stored are more or less frost proof in construction, and are fitted with ventilators in the roof and along the walls at the ground. A driveway extends through the center of the house with a row of bins along each side, as illustrated in Figure 17. These bins are commonly 3 to 4 feet in width wtih double-slatted partitions between, so constructed as to give approximately 6 inches of ventilating space between the bins from top to bottom. (Fig. 18.) In some houses these compartments are considerably wider, in which case the cabbage is generally stored on slatted racks which fit into the bins. From one to four layers of heads are placed on each rack and an air space of a few inches is left between the top layer of cabbages and the rack above. These racks aid greatly in the ventilation but add to the expense of handling and reduce the storage capacity of the house.

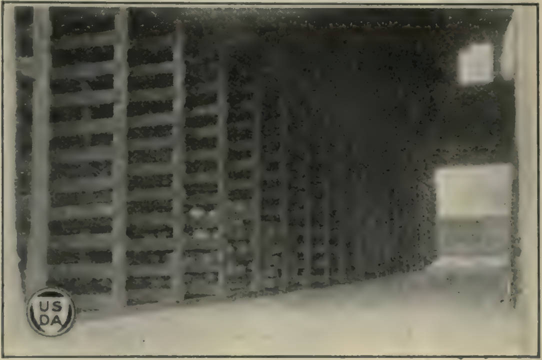
Fig. 17.—Usual arrangement of bins in cabbage storage house.

During severe weather it frequently is necessary to make provision for heating these storage houses. Stoves and coke heaters of the salamander type are usually employed. If the open coke heater is used the fire is lighted outside the building and the salamander is moved inside after the smoke has cleared away. During severe weather or periods of wide fluctuations in temperature, storage houses require frequent attention.

Cabbage to be stored should be green and solid, and should not show any yellowing, decay, mechanical injury, or other defects. If stored in these specially built warehouses, the heads should be trimmed to three to six tight wrapper leaves. Loose leaves interfere with ventilation, and thorough ventilation is essential.

In some northern sections field storage is practiced extensively. The cabbage is cut with the stem one-half inch or more in length, leaving several loose wrapper leaves. The heads are placed one layer deep on well-drained sod land, closely packed together with the stems down, and covered with a few inches of straw or hay, the depth of which is increased as the weather becomes colder.

In addition to these types of storage, considerable quantities are held for short periods in barns or cellars, or piled outside in long ricks or against strawstacks. The cabbage is stacked 3 or 4 feet high against a ventilating rack or A-shaped frame, and is then covered deeply with straw.

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[3] For further information regarding the storage of cabbage, see Farmers' Bulletin 433, Cabbage.

Upon removal from storage for shipment the stems are recut, and enough outer leaves are trimmed off to eliminate all defects and to give the heads a fresh appearance.

GOVERNMENT INSPECTION OF CABBAGE.

The development of the Federal fruit and vegetable inspection service in the past few years has been of great benefit in promoting fair and equitable business relations between buyers and sellers. The scope of this service was recently extended to include the inspection of cabbage at loading points in several States, and one of the most noticeable and far-reaching results has been the standardization of the shipments that originate in the sections where this service is available. The inspections are all made on the basis of the United States grades. Detailed information concerning the Government inspection of fresh fruits and vegetables may be secured upon application to the Food Products Inspection Service, Bureau of Agricultural Economics, Department of Agriculture, Washington, D. C.

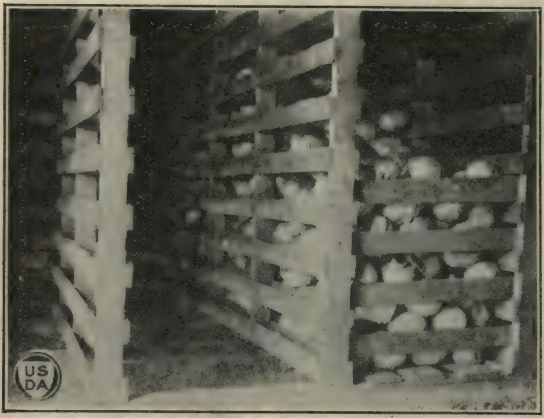

FIG. 18.—Approximately 6 inches of ventilating space is provided between the bins.

Although constant improvement is noticeable in the methods employed in preparing cabbage for market, and although many individuals and organizations exercise scrupulous care in maintaining their high standards, nevertheless the wide variation in the quality and condition of cabbage shipments that reach the terminal markets in the United States forces the conclusion that many shippers are still failing to devote as much attention to this phase of marketing as it deserves. In sections where standardized grades have been employed intelligently and consistently, marketing conditions have shown a decided improvement. It would seem, therefore, that the adoption of uniform and efficient methods of harvesting, grading, loading, and handling generally would be beneficial to all factors concerned in the distribution of cabbage.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1424

MAKING VINEGAR IN THE HOME AND ON THE FARM

VINEGAR can be made from any fruit, or, in fact, from any material which contains enough sugar and is in no way objectionable.

Whether it is done on a small scale in the home, on a larger scale on the farm, or on a still larger scale in the factory, the production of vinegar is the result of two distinct fermentation processes—an alcoholic fermentation followed by an acetic fermentation.

By using the materials and following the methods discussed in this bulletin, vinegar of good quality may readily be made from apples, peaches, grapes, and other fruits, large quantities of which are wasted each year in the United States.

Washington, D. C. Issued June, 1924

MAKING VINEGAR IN THE HOME AND ON THE FARM.

By **Edwin LeFevre**, *Scientific Assistant, Microbiological Laboratory, Bureau of Chemistry.*

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VINEGAR.

VINEGAR was first made from wine, as its name indicates, at a remote period. Biblical writers mentioned it and Hippocrates used it as a medicine. By the sixteenth century vinegar from grapes was being produced in France for home consumption and for export. In England vinegar was first made from malt liquors, a method of disposing of ale and beer which had soured. For this reason it was known as alegar. Although this name has long since become obsolete, malt vinegar is still the standard in the British Isles. It is not known just when vinegar was first made in the United States, certainly very early as a home product. Here apple juice is largely used for this purpose and cider vinegar is considered the standard for household purposes. Other fruits and vegetables, however, are coming more and more into favor for making vinegar. Spirit vinegar, now manufactured in large quantities in the United States, is extensively used for pickling purposes. There are few homes in which vinegar in some form is not used for flavoring, preserving, or pickling.

Vinegar is essentially a dilute solution of acetic acid, made by fermentation processes, containing salts and extracted matter. These additional substances, the exact nature and quantity of which depend upon the material used, give the product its distinctive quality. Sugar is the base of vinegar production. Any watery solution of a fermentable sugar may be transformed into vinegar under favorable conditions. Many fruit juices are well suited to this purpose, as they contain sugar in the proper proportion and other necessary or desirable substances.

All vinegar is made by two distinct biochemical processes, both of which are the result of the action of microorganisms. The first process is brought about by the action of yeasts which change the sugar into alcohol and carbon dioxide gas. This is the alcoholic fermentation. The second process results from the action of a widely distributed group of bacteria which have the power of combining oxygen with the alcohol, thereby forming acetic acid. This is the acetic fermentation, or acetification.

The following recognized varieties of vinegar are classified according to the material from which they are made and the methods of manufacture:

Vinegar made by the alcoholic and subsequent acetic fermentation of the juices of various fruits. Although apple juice is most commonly used for making vinegar in the United States, other fruit juices, notably those of grapes, peaches, oranges, persimmons, pineapples, and some berries, are satisfactory. Any fruit or vegetable containing enough sugar will serve the purpose.

Malt vinegar made by the alcoholic and subsequent acetic fermentation, without distillation, of an infusion of barley malt or other cereals in which the starch has been converted into maltose.

Sugar vinegar made by the alcoholic and subsequent acetic fermentation of solutions of sugar, sirup, or molasses.

Corn-sugar vinegar made by the alcoholic and subsequent acetic fermentation of a solution of cornstarch sugar or of glucose prepared from cornstarch.

Spirit or distilled vinegar made by the acetic fermentation of dilute distilled alcohol.

MATERIAL USED.

Anything may be used for making vinegar, so long as it contains enough sugar and is in no way objectionable. It would be difficult to describe in detail all the materials which are available for this purpose. The following are most commonly used in the United States:

APPLES.

Nearly all varieties of apples contain enough sugar to make vinegar of the required strength. This was well shown in three series of tests conducted by the Bureau of Chemistry on apples representing a large number of varieties grown during 1909, 1910, and 1911 in New York, Ohio, Virginia, Michigan, Missouri, and Washington. The average sugar content of the apples grown on grafted stock was found to be more than 13 per cent. In one series, including 58 varieties, in which two or more samples of each variety were analyzed (a total of 406 samples), the average sugar content was 13.34 per cent; in no sample was the sugar content less than 10 per cent. In a second series of 72 varieties, in which only one sample of each variety was analyzed, the average sugar content was 13.16 per cent; in only four of the varieties did the sugar content fall below 10 per cent. In a series of 75 samples of seedlings, natural fruit, the average sugar content was 12.71 per cent, the sugar content of none of the samples falling below 10 per cent.

Winter apples have the highest and summer apples the lowest average sugar content, with fall apples intermediate. Summer apples therefore are not suitable for vinegar making. Windfall apples may well be used for this purpose, provided they are not from summer varieties and were properly matured at the time of falling. Green apples are incapable of yielding a satisfactory vinegar, because much of their starch has not been transformed into sugar. Frosted or frozen apples have been used successfully for making vinegar, but they must be pressed soon after freezing and before any rotting occurs.[1] Contrary to the usual belief, sweet apples are not richer in sugar than sour apples; in fact, some varieties may contain less than the average quantity. The sweet taste of these apples is due not to the presence of larger quantities of sugar but to a deficiency in malic acid, the acid normally present in apples.

Evaporated apple chops and the evaporated cores and parings obtained from apple-canning factories and apple-drying establishments are now used to some extent in the commercial production of vinegar. By passing water through several successive tanks of this material it is possible to obtain a sweet solution which serves for the production of vinegar. If the dried stock used for this purpose is clean and made from sound material, vinegar of satisfactory quality may be produced in this way. Such vinegar, however, is not made from the expressed juice of apples, so that when offered for sale it must be marked to show the material from which it is made.[2]

GRAPES.

Vinegar of unexcelled quality can be made from the grapes (*Vitis vinifera*) grown in Europe and on the Pacific coast of the United States. The white wine vinegar made from whole white grapes or from the pulp of purple or red grapes is excellent in quality. This must not be confused with what in commerce was formerly incorrectly called " white wine vinegar," which is simply a spirit vinegar. Grape vinegar can compete commercially with cider vinegar only on the score of merit and if it is to be sold at a profit " it must be made in such a manner as to produce and preserve those qualities to which it owes its reputation for superiority over all other classes of vinegar." [3]

Grape juice contains a very much higher proportion of sugar than apple juice; hence a much stronger vinegar can be made from it. The California Agricultural Experiment Station has shown that a ton of California grapes (20° Brix) can give on an average 150 gallons of juice, which will yield 135 gallons of vinegar containing 9.8 per cent of acetic acid. The Bureau of Chemistry has shown that vinegar of excellent quality can be made from the muscadine grapes grown in the Southern States. Juice from four varieties of these grapes (16.5° Brix) gave by household methods vinegar which contained an average of 6.6 per cent of acetic acid.

ORANGES.

The Bureau of Chemistry has shown that a very acceptable vinegar can be made from oranges, either on the household scale or on a commercial scale. Cull oranges will give a vinegar which not only is equal to the best grade of vinegar but can be made commercially at a cost which in some markets permits competition in price with apple vinegar.

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[1] A. R. Lamb and Edith Wilson. Vinegar Fermentation and Home Production of Cider Vinegar. Iowa Agr. Expt. Sta. Bul. 218 (1923), p. 5.

[2] U. S. Dept. Agr., Food Inspection Decision 140 (1912).

[3] F. T. Bioletti. Grape Vinegar. Calif. Agr. Expt. Sta. Bul. 227 (1912), 26 pp.

PEACHES.

While the average sugar content of peaches is somewhat lower than that of apples, certain varieties contain enough sugar for vinegar making. Juicy varieties of the Carman type are best adapted for this purpose. The peaches should be tree-ripened if possible, for tree-ripened peaches apparently contain more sugar than those picked while green and allowed to ripen during shipment or storage.[4] Peach juice ferments readily and vinegar of good flavor can often be made from peaches which would otherwise be allowed to decay.

PERSIMMONS.

Persimmons, which grow in nearly all parts of the United States, but most abundantly in the Southern States, are exceedingly rich in sugar. Experiments conducted in the Bureau of Chemistry have shown that they may be utilized for making vinegar. In using fruits like persimmons and figs, which have a high sugar and low moisture content, water must be added in order to secure the proper concentration.

PEARS.

Grown in great abundance in many places, pears also may be utilized for making vinegar. Investigations in the Bureau of Chemistry have shown that even varieties like the Kieffer, which have a low sugar content, if well ripened may be made to produce a satisfactory vinegar.[5]

BERRIES.

Vinegar which can readily be made by household methods from raspberries, blueberries, and doubtless other berries may be very acceptable for certain purposes. Experiments in the Bureau of Chemistry have shown that vinegar made from red raspberries will retain indefinitely the odor and flavor of the fruit, which makes it desirable for flavoring food. Vinegar made from berries is dark, but it can easily be made clear or " bright " (p. 15).

HONEY.

Vinegar of excellent flavor can be made from unmarketable honey or honey washings. When honey is used for this purpose, it must, of course, be diluted by the addition of water until it contains about 15 per cent of sugar. As heat must be employed in the process of dilution, it will be necessary to use cultures of yeast and acetic bacteria (p. 12). The dilution of the honey also reduces the chemical elements which are necessary for the growth of the yeasts and bacteria. In order to supply the essential elements, especially nitrogen and phosphates, certain chemicals should be added. The following formula is suggested for a barrel of vinegar: Strained or extracted honey, 40 to 45 pounds; water, 30 gallons; ammonium phosphate, 2 ounces; potassium tartrate, 2 ounces.

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[4] W. D. Bigelow and H. C. Gore. Studies on Peaches. U. S. Dept. Agr., Chem. Bul. 97 (1905), 32 pp.

[5] H. C. Gore. The Preparation of Vinegar from Kieffer Pears. *In* J. Am. Chem. Soc. (1907), vol. 29, p. 759.

MAPLE PRODUCTS.

Maple-sirup skimmings or maple sirup which has been scorched may be used for making vinegar. Like honey, this must be diluted until it contains about 15 per cent of sugar, or until it weighs 9 pounds to the gallon. To each 30 gallons of the diluted sirup, 2 ounces each of ammonium sulphate and sodium phosphate are added. These chemicals, which are neither expensive nor injurious in the quantities called for, are not to be regarded as adulterants.[6]

WATERMELONS.

Watermelons have been used successfully for making vinegar, but the juice must be concentrated to about half its original volume to give the proper sugar content.

GRAINS.

Grains, chiefly corn, barley, rye, and oats, are largely utilized for the production of spirit and malt vinegar. The starch which they contain is first converted into sugar, usually by the action of malt (sprouted barley). Malt vinegar is made from the sugary solution or wort obtained by steeping crushed malt in warm water.

MOLASSES.

Molasses, either alone or in combination with grain extracts, is widely used as a basis for making spirit vinegar. Crude molasses, known as blackstrap, is first diluted with hot water and then subjected to alcoholic fermentation. The "low wines" which are obtained by distilling the fermented product are then run through generators and converted into spirit vinegar. Much of the spirit vinegar now used is made from alcohol obtained as a by-product from the manufacture of other products, notably compressed yeast.

Distilled or spirit vinegar which is made in this way is nearly colorless and lacks the aroma and flavor of fruit vinegars. For this reason it is not commonly preferred for table use, but is extensively used for pickling and preserving.

FERMENTATION.

The methods of making vinegar differ decidedly, depending upon whether it is made in small quantities as a household product, in larger quantities as a farm product, or in much larger quantities requiring the elaborate equipment of a commercial plant. The first two methods will be discussed in detail; the last method, which involves many technical details, can not be fully treated here.

HOUSEHOLD METHOD.

Fruit enough to make all the vinegar for a year's supply is wasted in many homes. Surplus or inferior grades of fruit not desired for immediate use or for canning may often be turned into a useful product at a merely nominal cost. Experiments in the Bureau of Chemistry have shown that vinegar of legal strength (4 per cent acetic acid) can be made from all of the fruits listed on page 2, although it may not be possible to use all varieties. In order to avoid disappointment, a test should be made to determine the sugar content of each lot of fruit before beginning the operation (p. 24). In making vinegar for home consumption and not for sale the need of a product of full legal strength is not imperative.

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[6] Directions for Making a Good Flavored Cider Vinegar. Mich. Agr. Expt. Sta. Special Bul. 98 (1920), 24 pp.; A. E. Vinson. Honey Vinegar. *In* Ariz. Agr. Expt. Sta. Bul. 57 (1907), pp. 247–255.

The best receptacles for making vinegar in the home are stone jars. These should always have straight sides and open tops and should be provided with covers. (Fig. 1.) Jars holding from 3 to 6 gallons are ordinarily used for this purpose.

With most of the fruits used it is impossible or inexpedient to separate the juice from the pulp before the alcoholic fermentation has taken place. The proper method, therefore, is to make a yeast inoculation into a mash of the fruit. With some fruits, like apples, oranges, or pineapples, from which the juice can be readily expressed, it may be better to use the juice only. Even with apples, however, it is probable that a more complete utilization of sugar would result if the alcoholic fermentation were carried out in the crushed fruit.

The following method which calls for peaches may be used, with a few minor variations, for making vinegar from other fruits.

PREPARATION OF MASH.

Ripe fruit should, of course, always be selected. Overripe fruit is not to be barred; in fact, in some instances it is preferable, so long as decayed portions, which would introduce objectionable flavors and organisms, are carefully removed. Juicy peaches are best, although almost any kind can be utilized.

Enough peaches (approximately 1 bushel) to fill a 4-gallon stone jar about two-thirds full when made into a mash are cut in two and crushed with a potato masher. The stones need not be removed.

ALCOHOLIC FERMENTATION.

A cake of compressed yeast which has been mixed in a small portion of the juice is added to the jar of peach mash. The jar is covered with a double layer of cheesecloth to prevent the entrance of insects and with a cover to exclude light. The mash is stirred daily to break up surface crusts, prevent the formation of molds, and insure a more complete fermentation. Stirring also prevents the action of acetic bacteria. As a rule from 4 to 6 days are necessary for this fermentation.

ACETIC FERMENTATION.

When the alcoholic fermentation is complete the juice is separated from the mash. Usually by this time separation has to a great extent been accomplished by the action of the yeast and straining through cheesecloth is all that is necessary. Complete separation may require the use of a hand press.

After the juice has been returned to the jar a starter (p. 13) in the form of vinegar is added in the proportion of 1 part to 4 parts of the juice and the jar is covered as before. Within a few days a thin coating or film will appear on the surface of the juice. This " mother of vinegar," which is composed almost entirely of acetic bacteria, is essential for a successful fermentation. Great care, therefore, should be taken not to cause it to fall by stirring or agitation.

During the acetic fermentation frequent tests should be made to determine the increase in acidity (p. 25). As soon as this has reached its maximum, the vinegar is filtered (p. 15) and bottled (p. 19).

VARIATIONS.

This procedure may need to be varied in some respects for different fruits. For example, when fruits which have very high sugar contents, like persimmons, are used it is necessary to add water to the mash before inoculating with yeasts. An equal quantity by weight of water added to the persimmon mash will usually give the desired sugar content.

The plan outlined is believed to offer the best method of making vinegar in the household. It is the simplest and the least expensive and gives satisfactory results. Anyone who has a supply of surplus fruit, 2 or 3 large stone jars, a few cakes of compressed yeast, and 3 or 4 quarts of good vinegar to act as a starter can in this way make all the vinegar that is required by an ordinary family for a year. Vinegar with an acetic acid strength of 4.5 per cent has been made from peaches by this method in 13 days.

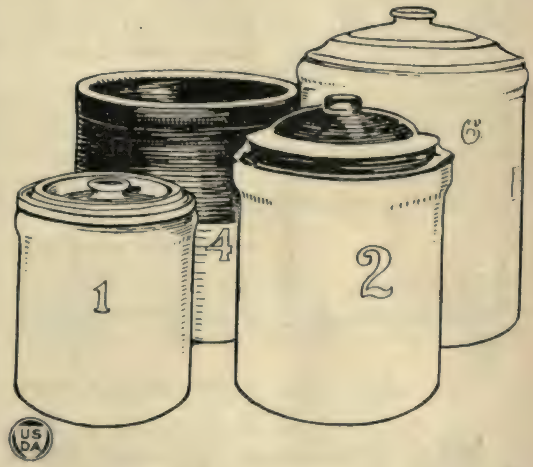

Fig. 1.—Suitable receptacles for making vinegar in the home.

FARM METHOD.

Vinegar as ordinarily produced on American farms is made from apple juice, although there is no good reason why grapes, peaches, or pears should not be used when their prices are not prohibitive.

PRESSING THE FRUIT.

Almost any apples may be used except those which are green or rotten. If partly rotten apples are used the rotten spots should be cut out and the apples washed. Dirty apples should be washed. Dirt, grass, or leaves should not be allowed to go into the press with the apples; they will injure the flavor of the vinegar and may retard the process.

The apples should not be ground too fine; they should be crushed rather than ground. Too fine grinding makes it difficult to press out the juice. Pressing must be done slowly and as much as possible of the juice extracted. From 2 to 3 gallons of juice should be obtained from a bushel of apples. The "press cloth" type of press is the most efficient for this purpose. Full directions for pressing apples are given in Farmers' Bulletin 1264.

Second pressings from fresh pomace may be made when desired. If water is added to the pomace, however, the resulting juice will be low in sugar and other solids. The addition of such juice to the juice from first pressings may reduce the sugar content of the whole to a degree which would not permit the production of a satisfactory vinegar. If the vinegar is made for sale, Federal food regulations require that the addition of water in the process of manufacture must be plainly indicated on the label.

ALCOHOLIC FERMENTATION.

After being expressed, the juice should stand for a day or two in loosely covered barrels or other covered receptacles for sedimentation, after which it is carefully drawn off, preferably by the use of a siphon (p. 15), and transferred to other containers for alcoholic fermentation. These barrels should not be filled over three-fourths full.

Compressed yeast is added in the proportion of 1 small cake for each 5 gallons of juice. The yeast should first be thoroughly macerated in at least a quart of the juice and this should be well stirred into the whole. If a pure culture of a specially cultivated yeast is to be used, this should be prepared and added as directed on page 13.

ACETIC FERMENTATION.

The second or acetic fermentation may be done in any one of the three following ways. The selection of the process will, of course, depend upon individual conditions.

SLOW BARREL PROCESS.

After the alcoholic fermentation is complete, as shown by a test (p. 25), the juice should be carefully drawn off from the containers in which the alcoholic fermentation took place, without disturbing the settlings at the bottom, and passed into barrels for the final or acetic fermentation. The barrels should have been first thoroughly cleaned and soaked with strong vinegar and placed on their sides with the bungholes up. They are filled about two-thirds full, the aim being to expose as large a surface of juice as possible to the air. About 3 gallons of good vinegar is then added to each barrel to hasten the change to acetic acid. For this purpose a fresh unpasteurized vinegar is much to be preferred, but if it is not obtainable any good strong vinegar will do.

The alcohol of the yeast-fermented juice is now turned into acetic acid. In order that this change shall take place rapidly, the juice must be in contact with the air. For this reason the bungholes should be left open. Additional holes should be bored in the ends of the barrels to afford a free circulation of air. Pieces of cheesecloth or well-varnished fine wire screen should be tacked over all openings to keep out insects and dirt. The temperature should not be below 70°F., if practicable.

Acetification should be allowed to proceed until a strong vinegar is produced. Such a vinegar can be recognized by its taste, but it is much safer to determine the degree of acidity by tests as the acetification progresses (p. 25). If a good starter has been added and the juice is kept at the proper temperature, the time required to convert the alcohol in the juice into acetic acid should not be more than 3 to 6 months.

CONTINUOUS PROCESS.

The process of acetification may be made continuous by adopting the following plan,[7] which is essentially the Orleans method that has been used from time immemorial in the Orleans district of France:

A barrel holding about 50 gallons is made into a "converter" (fig. 2). In one end of the barrel, just above the center, a 2-inch hole (A) is bored and in the other end, about an inch below the stave containing the bunghole, another hole (B) of the same size. The holes are covered with mosquito bar or well-varnished fine wire screen to keep out the small vinegar or fruit flies. The spigot (C) is fitted in place. With the aid of a hot iron, a hole is bored through the cork used for closing the bung. In this hole is fitted the stem of a short glass or rubber funnel, running about half of the way through. A piece of bent glass tubing, about one-half inch in diameter and long enough to reach within 3 inches of the bottom of the barrel, is also fitted in the hole.

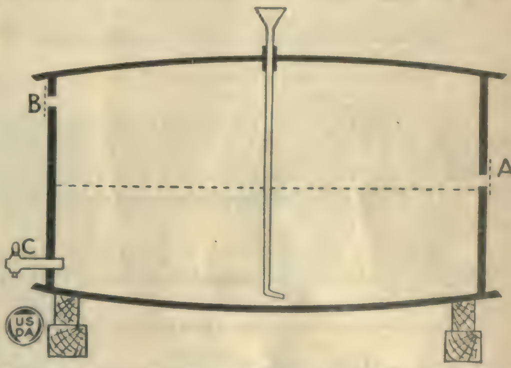

FIG. 2.—Converter for continuous process. *A* and *B*, 2-inch holes; *C*, spigot.

The finished converter is blocked firmly into place where there is a free circulation of air and about 3 gallons of fresh, unpasteurized vinegar is poured into it. The clear yeast-fermented juice is now run in until the surface of the liquid is nearly level with the air hole (A). Better results would probably be obtained by adding the juice in the fractional parts of one-fourth to one-third at intervals of a week. An additional advantage would be secured in all of these operations if the juice were heated to 85° or 90° F. before being poured into the converter.

The converter is allowed to stand without disturbing the film which forms on the surface until the acetification has gone far enough. When 4.5 to 5 per cent of acetic acid has been produced the vinegar is drawn off through the spigot, leaving about 3 gallons. The transfer of the vinegar should be made slowly so as not to break the film.

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[7] Adapted from Farm-Made Cider Vinegar. Iowa State Dairy and Food Commission Bul. 12 (1915).

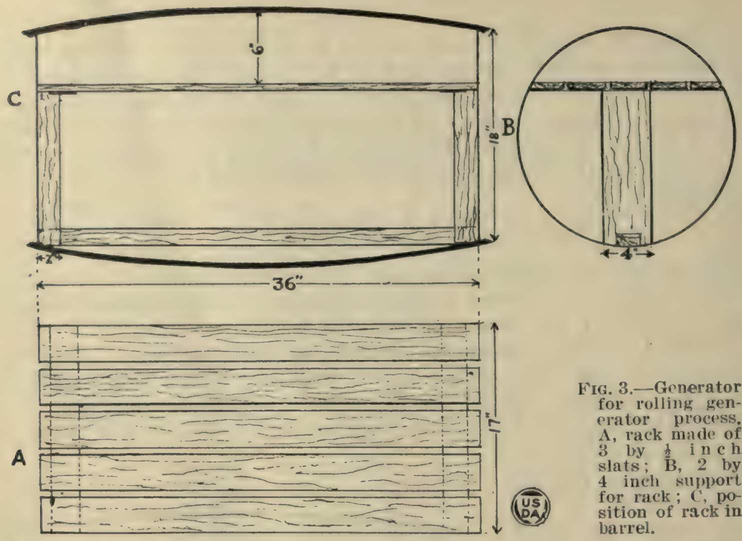

FIG. 3.—Generator for rolling generator process. A, rack made of 3 by ½ inch slats; B, 2 by 4 inch support for rack; C, position of rack in barrel.

A new supply of yeast-fermented juice is now slowly run in through the funnel which leads to the bottom of the converter. This should be done carefully so as not to disturb the surface film. The film will rise on the surface of the liquid and start fermentation promptly.

A converter made from a 50-gallon barrel should convert from 100 to 150 gallons of yeast-fermented juice into vinegar in a year.

ROLLING GENERATOR PROCESS.

The so-called rolling generator process, which greatly shortens the time required for acetification, approaches more nearly the commercial process of making vinegar in generators. This plan requires more work and attention than the slow barrel method, but by providing for a greater circulation of air it greatly hastens acetification.

An ordinary vinegar barrel is made into a generator[8] as follows (fig. 3): After one head of the barrel has been removed, a small rack is built into the barrel in such a way as to make throughout its length, about 6 inches below the bunghole, a compartment which is to be filled with beechwood shavings or corncobs (C). A quick way to do this is to make a rack of slats 3 inches wide by one-half inch thick, set into grooved end pieces, with about one-half inch of space between them (A). At each end this rack is supported by a 2 by 4 inch piece cut in such lengths that the rack will be at least 6 inches below the bung (B). The 2 by 4's are usually joined at the bottom by a crosspiece 1 by 2 inches. After this rack is set in place and the compartment is filled with cobs or shavings, the barrel is reheaded and three 1-inch holes are bored obliquely downward in each end, so that the openings come just beneath the bottom of the rack holding the shavings or corncobs. In constructing the rack and fastening it to the 2 by 4's, grooves or dowels should be used, or, if more convenient, the rack may be held together by hardwood pegs. Iron or other metallic nails should not enter into the construction.

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[8] E. M. Chace. By-Products from Citrus Fruits. U. S. Dept. Agr. Cir. 232 (1922), pp. 4, 5.

When used for the first time or after it has been standing idle for any length of time, the generator should be thoroughly scalded with hot water or steam. After the generator has been completely drained, about 1 gallon of fresh unpasteurized vinegar is poured into it. All the holes are tightly plugged, and the generator is turned to allow the vinegar to run over and saturate the shavings. The generator should then be filled about half full with yeast-fermented juice. Several times each day, if possible, but at least once a day, all the holes should be closed with wooden pegs and the generator rolled over, so that the bung is at the bottom, and shaken three or four times to bring the juice thoroughly in contact with the beechwood shavings or corncobs. The generator is then rolled back into its original position and the wooden pegs are replaced by cotton plugs. As there is a circulation of air from the end holes through the

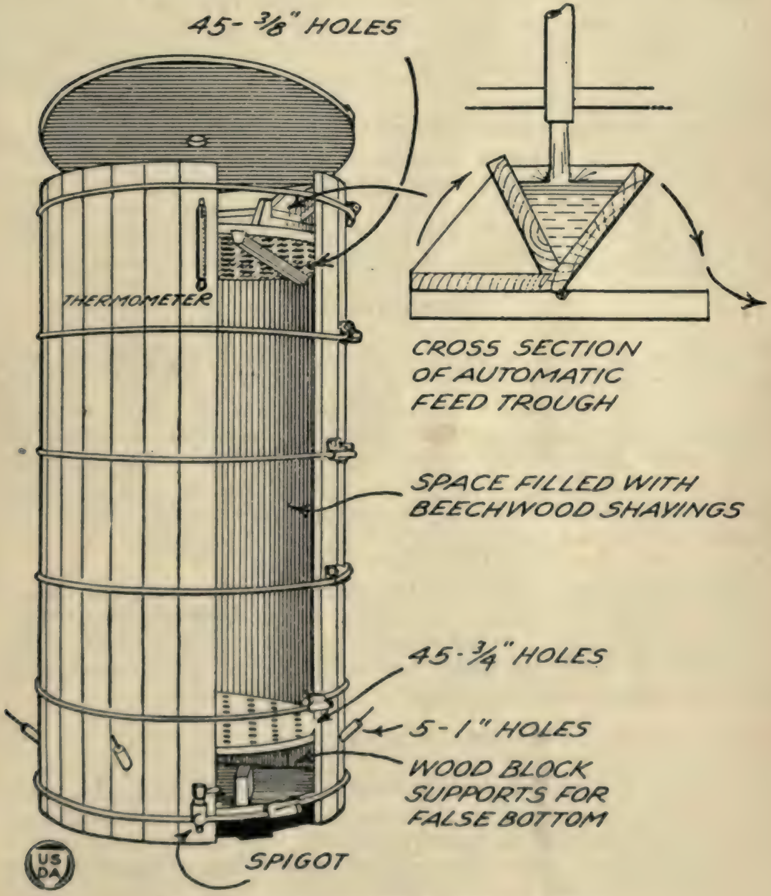
45-3/8" HOLES
THERMOMETER
CROSS SECTION OF AUTOMATIC FEED TROUGH
SPACE FILLED WITH BEECHWOOD SHAVINGS
45-1/4" HOLES
5-1" HOLES
WOOD BLOCK SUPPORTS FOR FALSE BOTTOM
SPIGOT
US DA

FIG. 4.—Generator for quick or generator process.

shavings out of the bunghole, the juice dripping from the shavings comes in contact with the air, as a result of which the process of acetification is greatly hastened.

As the fermentation progresses, a good deal of heat is developed. To obtain the best results the temperature of the upper portion of the generator should be kept at about 85° F. The temperature can be lowered by inserting some of the pegs to cut down the air current passing in at the holes. To raise the temperature the supply of air is increased by removing some of the pegs.

If the generator is rolled every day and the temperature is maintained at from 80° to 85° F., the juice may be converted into good vinegar by this method in from 60 to 90 days.

COMMERCIAL METHOD (QUICK VINEGAR PROCESS).

The farm method of making vinegar is necessarily slow, for the reason that only the surface of the alcoholic liquid is exposed to the air. It is possible to greatly hasten the production of acetic acid by allowing the alcoholic mixture to trickle slowly through a tall wooden vat containing material like wood shavings, coke, or corncobs which has been inoculated with acetic bacteria and through which a current of air is constantly rising. Such an apparatus is known as a generator (fig. 4) and this method is called the quick or generator process of making vinegar.

By using generators more vinegar can be made in a few days than could be made in as many months or even years by the ordinary farm procedure. For this reason generators are always used where vinegar is produced commercially in large quantities. As this method is a continuous process which calls for an extensive equipment and trained supervision, it is not practicable for farm use.

CLEANLINESS.

Cleanliness is essential in all methods. Anything that will produce malfermentation or off flavors should be avoided. To this end all utensils and receptacles must be kept clean. Not only must the barrels be clean but they must also be free from anything which will impart undesirable flavors or odors to the vinegar. Barrels which have been used for storing paints, oils, varnishes, or industrial alcohol should never be used for this purpose. Old vinegar and molasses barrels and new barrels should not be used until they have been well washed with boiling water or steam.

Barrels which have been used for grain alcohol, whisky, or brandy are well adapted for vinegar making. These liquors are antiseptic to most microbes, but in small quantities they are not antagonistic to the growth of yeasts or acetic bacteria and will not impart undesirable flavors or odors to vinegar.

USE OF STARTERS.

Experience has thoroughly demonstrated the value of the use of starters in making vinegar. Yeasts and acetic bacteria are practically always present in fruit juices, but they often occur only in limited numbers or more often are of undesirable or inactive types.

Better results are obtained by the addition of active strains. This is especially important in the alcoholic (yeast) fermentation where a prompt and rapid fermentation is desirable.

Ordinary compressed yeast, obtainable almost everywhere in this country, is a satisfactory starter for the alcoholic fermentation and should be used when it is impossible to obtain cultures which have been especially cultivated for vinegar production.

As a starter for the acetic fermentation, the best results are undoubtedly obtained by the addition of vinegar. If possible, unpasteurized vinegar should be used, for the reason that such vinegar usually insures the addition of the essential organism. Vinegar should be added as a starter in any event, however, whether or not it contains living bacteria, and even when a pure culture of acetic bacteria is used.

When pasteurized juices or sugar solutions, which do not contain the essential organisms, are used for making vinegar, the addition of active cultures is of course essential.

For those who desire to use pure cultures which have been cultivated especially for vinegar production these directions are given.[a] The cultures should be obtained only from sources which insure their reliability. Such cultures are furnished by several of the State experiment stations and by some commercial laboratories. Yeast cultures should be obtained about a week before they are to be used. From these a starter in a 2-quart fruit jar is prepared for each barrel as follows:

STARTER FOR ALCOHOLIC FERMENTATION.

Wash the jar thoroughly and sterilize it in boiling water.

Immediately fill the jar half full with boiling apple juice. If no sweet juice is available, slice five or six ripe apples in 2 quarts of water and boil until the fruit is soft. Add 4 tablespoonfuls of molasses or 2 tablespoonfuls of sugar and strain about 1 quart of the boiling juice into the fruit jar.

Cover the jar immediately with a few folds of cloth, sterilized with boiling water, to keep out germs from the air.

When the liquid has cooled to 75° F., shake the bottle labeled "vinegar yeast" and empty the contents into the jar.

Keep the jar at a temperature of 70° to 80° F.

When foaming is very active, empty the contents of the jar into the barrel of sweet juice. Cover the bunghole with a thin cloth to keep out dust, without cutting off the air.

Immediately after the active foaming in the barrel ceases, send to the bacteriological laboratory for the acetic culture and prepare it as follows:

STARTER FOR ACETIC FERMENTATION.

Draw off a quart of the yeast-fermented juice into as many jars as there are barrels to be inoculated. Observe the foregoing precautions for keeping the jars clean and sterile.

Pasteurize the liquid in the jars by bringing it just to the boiling point in hot water; then allow it to cool to 75° F. Do not let it boil.

Add the culture labeled "vinegar bacteria" to the jar, cover as before, and keep it at a temperature of 80° F.

Do not disturb this jar. Mother of vinegar (*Bacterium aceti*) will appear on the surface of the liquid in a week or so as a smooth grayish-white glistening film. If molds develop do not use the starter but send to the bacteriological laboratory for another.

When this film is one-sixteenth to one-eighth inch thick, lift it out of the jar with a clean boiled splinter of wood, add the contents of the jar to the barrel, and float the film on the surface of the liquid, using the splinter as a raft. It is very important that this film be floated on the surface.

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[a] Adapted from directions given by the Washington State Agricultural Experiment Station for preparing pure cultures for vinegar making.

Do not disturb the barrel from now on except to remove small quantities from time to time to test the strength of the vinegar (page 25).

AFTER TREATMENT.

After vinegar has been properly fermented and has reached the desired degree of acidity, it is most important to see that it does not deteriorate in strength or quality. To this end, it must not be exposed to the air. The presence of air, which was so important during acetification, is now to the same degree undesirable. Free exposure to air would mean that the acetic and possibly other types of microorganisms would continue to act. As a result the acid would be attacked and sooner or later the vinegar would be reduced to a worthless condition. To prevent this, it is necessary only to keep the vinegar in completely filled containers, tightly sealed.

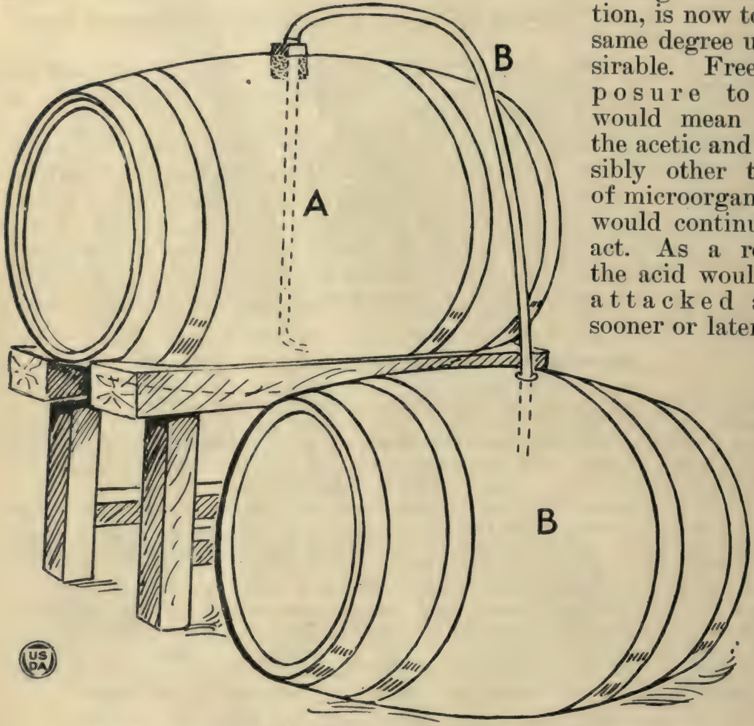

FIG. 5.—Siphoning off the vinegar. *A*, glass tube; *B*, rubber hose.

When vinegar is made under household conditions, as soon as it reaches the desired acidity it should be decanted off, filtered, and bottled. When made under farm conditions and stored in barrels or in kegs, the containers should be kept completely filled, tightly bunged, and stored, preferably in a cellar where a cool, even temperature prevails.

AGING.

Vinegar has a raw, biting taste when first made but it becomes more mellow during storage. The flavor and aroma characteristic of the best grades of vinegar made from apple and grape juice are due to the esters which are formed during storage. Storage for from six months to a year is required for vinegar to attain its highest quality.

CLARIFICATION.

The aging of vinegar is valuable for the additional reason that it affords a chance for settling. In many cases vinegars which are not clear at the end of fermentation will become clear on standing.

After vinegar has been held in storage for several months it should be "racked off," that is, drawn off carefully, so as not to disturb the sediment, and with as little exposure to the air as possible. This is best done by the use of a siphon. (Fig. 5.) For this purpose the glass tube (A) described on page 9 may be utilized by simply attaching to the upper end a piece of rubber hose (B). This process should be repeated if the vinegar is to be held in storage very long. Usually this will yield a product which is fairly clear and for home use may be all that is desired. If intended for sale, however, good commercial practice demands that it be perfectly clear or bright.

Juices from certain fruits, notably that from most varieties of apples, show a marked tendency to clear during fermentation. Others, like that from peaches, do not, and often can be made perfectly clear only with great difficulty. Cloudiness in vinegar may be due to the presence of finely divided particles or colloidal substances held in suspension, or to the presence of bacteria or the products of bacterial activity. Certain strains of acetic bacteria show a marked tendency to produce cloudiness of the medium in which they grow. In order, therefore, that a vinegar may be perfectly clear and bright, it is usually necessary to resort to filtration or to the use of clarifying agents.

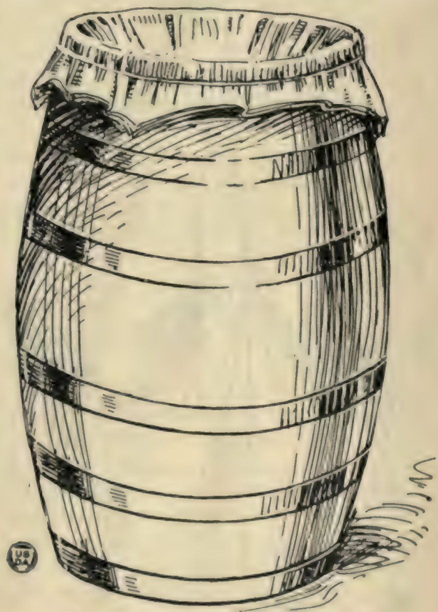

Fig. 6.—Filter over top of barrel.

FILTRATION.

The common method of securing a perfectly clear vinegar is by means of filtration, which usually is effectual if properly done.

When the quantity of vinegar to be filtered is not large, it may be passed through a filter made by folding a large piece of canton flannel so as to give three or four thicknesses. This may be simply placed over a convenient receptacle (fig. 6) or it may be made up in the form of a cone-shaped filter bag (fig. 7). It may be necessary to pass the vinegar through a filter of this kind several times to make it clear or bright. The efficiency of a cloth filter, and in fact of practically all filters, depends upon the gradual filling up of the pores of the filtering medium by particles of the material passing through it. Hence perfect clarification is not often accomplished by one filtration, or at least the first portion to pass through is not clear and must be poured back for refiltration.

When larger quantities of vinegar are to be filtered, as in commercial production, filters of more or less elaborate construction are used. These usually operate by suction and filtration is made through various substances, such as cloth, paper or cotton pulp, or diatomaceous earth. Metals which are readily attacked by acetic acid must be avoided in the parts of the filter which come in contact with the vinegar.

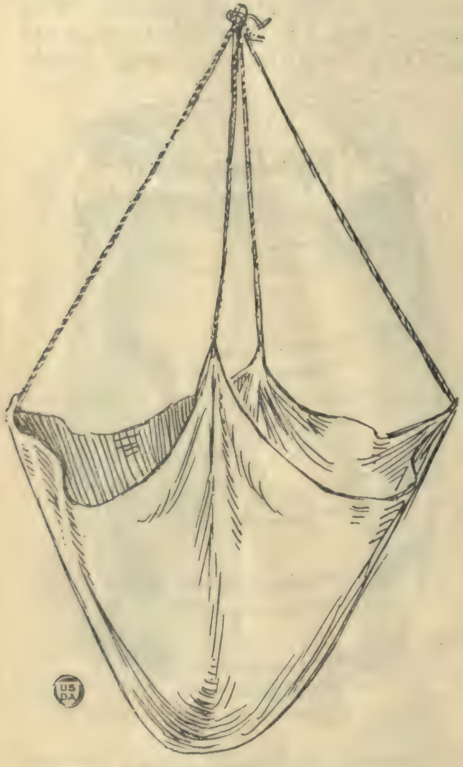

FIG. 7.—Filter bag.

CLARIFYING AGENTS.

In some vinegars which are persistently cloudy filtration alone may not be effectual for clarification. In such cases a clarifying agent, either alone or as an aid to filtration, must be used. An inert insoluble substance is preferred for this purpose.

Diatomaceous earth, commonly used for clarifying vinegar, has a high adsorbing power and when properly selected and prepared has no undesirable effect on the product. If this earth contains calcium carbonate it should be rejected. The organic matter usually present to some extent can be removed by heating the earth to redness. It should be added to the vinegar in the proportion of one-half to 1 ounce to the gallon (4 to 6 pounds to 100 gallons), well stirred in order to form an intimate mixture with the vinegar, and at once filtered through a cloth containing a thin moist layer of the same earth.

Animal charcoal or some of the vegetable carbons are sometimes used for clarifying vinegar. These, however, usually contain alkaline salts, which, to some extent at least, lower the acidity of the vinegar, and may also have an unfavorable effect on its flavor. Another objection to the use of carbons is that the finer particles filter out with difficulty and, unless the filtering is very carefully done, they may on standing form a deposit on the sides and bottoms of containers.

As the carbons are active decolorizing as well as clarifying agents, they are sometimes used for clarifying grape vinegars made from dark wines which might otherwise be unmarketable.[10] They must, however, be used with caution and only after a preliminary test to determine the quantity necessary in each case. They are to be thoroughly stirred into the vinegar just before filtration.

When vinegar is made in the home from fruits like prunes and various berries which give a dark-colored product, the color need not be removed. It is only necessary that the vinegar should be made clear or "bright."

Gelatinous or albuminous substances which produce a heavy precipitate when mixed with vinegar have long been used and are widely recommended as a means of clarification. When it is desired to clarify vinegar in this way one-half ounce of a good grade of edible gelatin to a barrel of vinegar should be used. The gelatin must first be covered with about a quart of water, allowed to stand for a few hours, and heated until completely dissolved. The solution is then added to the vinegar and mixed thoroughly by stirring. After standing for some time the gelatin settles, leaving a clear liquid. The clear liquid should be siphoned off (p. 15) and the sediment drained off and filtered. The success of this method of clarification depends upon the perfect precipitation of the gelatin which results from the presence of tannin. In many vinegars tannin is present in such small quantities that more tannin must be added if clarification is to be accomplished by the use of gelatin. The tannin (about one-fourth the quantity by weight of gelatin used) should be added several hours before the gelatin is added.

Ordinarily a clear vinegar may be obtained by the use of agents which act chemically and under certain conditions their use may be justifiable (p. 22). This method of clarification, however, is open to the following serious objections: (1) It means the addition of a foreign substance which goes into solution in the vinegar and may have an unfavorable influence on the flavor of the product; (2) these agents act slowly and their use involves loss of time and extra labor and expense; (3) the addition of some of these materials favors the growth of microorganisms and is therefore objectionable unless followed at once by pasteurization.

PASTEURIZATION.

Pasteurization is always to be considered as one of the measures for preserving vinegar and maintaining its strength. The deterioration of vinegar is usually the result of the continued activity of the acetic organisms. Even after filtration or clarification, vinegar contains bacteria which upon being exposed to the air grow and multiply, making the vinegar "mothery" and perhaps cloudy. This condition may be prevented by pasteurization, which is sometimes done as soon as acetification is completed. As the same end may be accomplished by storage in air-tight containers which are completely filled, however, pasteurization is usually deferred until the vinegar is transferred to its final containers.

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[10] F. T. Bioletti, loc. cit.

The proper temperatures for the pasteurization of vinegar range from 140° to 160° F. Experience has shown that if properly carried out a temperature of 140° F. is effectual for this purpose, but it is the minimum—no lower temperature can be depended upon to produce the desired result. On the other hand, a temperature of 160° F. should not be exceeded, for the reason that it is not required and may cause an unnecessary loss of acetic acid by evaporation.

Under household or farm conditions pasteurization may be accomplished by simply heating the vinegar to the required temperature in kettles or other large containers. Only the best unchipped enameled ware should be used. The entire volume of the vinegar must be brought to an even temperature. This can be done by stirring during the heating process and by using a reliable thermometer. After being cooled to about 70° F., the vinegar is at once transferred to the final containers, which should have been previously sterilized in hot water or steam. They should be filled full and immediately sealed with sterilized stoppers.

Vinegar may be readily pasteurized after it has been transferred to the final containers by submerging the tightly sealed containers in water and heating to the required temperature. For pasteurizing on a small scale, an ordinary tin wash boiler, with a wooden rack in the bottom to permit circulation of water and having a long-stemmed thermometer suspended through a hole in the cover, makes a very satisfactory outfit.[11] Jars or bottles should be placed in the boiler either on their sides or inverted in order to insure the destruction of any organism on the stoppers.

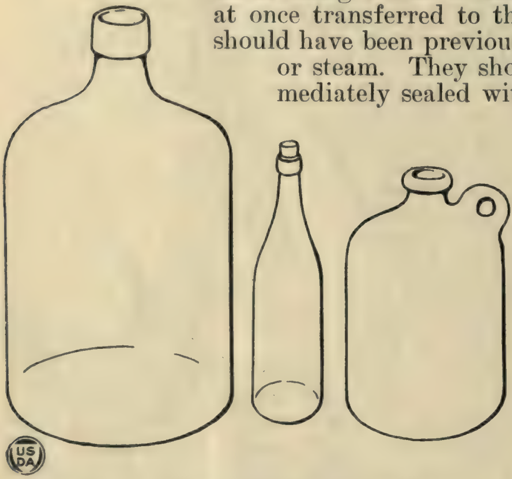

FIG. 8.—Glass containers for vinegar.

For pasteurizing vinegar on a larger scale or in large containers, a pasteurizing tank is necessary. Vinegar pasteurized in this way will not reach the desired temperature as soon as the surrounding water. This additional time, which is proportional to the size of the containers, varies from 5 minutes for a pint container to 25 minutes for one holding 2 gallons. Allowance must also be made for the expansion of liquids from heat. Containers, therefore, should not be filled entirely full. A rise in temperature from 60° to 140° F. would cause an expansion of about 2 per cent in volume.

Under commercial conditions vinegars are usually pasteurized by the continuous method. The vinegar is heated to the required temperature by being passed through coils of pipe surrounded by steam and then to other coils covered by cold water, which again cools it to about 70° F. Under the usual factory procedure, vinegar that has been properly aged is first filtered, then pasteurized, and poured at once into the final containers.

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[11] J. S. Caldwell. Farm Manufacture of Unfermented Apple Juice. U. S. Dept. Agr. Farmers' Bul. 1264 (1922), pp. 33–34.

Pasteurization also is believed to assist the maturing of vinegar, giving it a softer and more pleasing taste and aroma. This it probably does by hastening the combination of the residual alcohol in the vinegar with the acetic acid, thereby favoring the formation of esters.

PACKING.

After vinegar has been properly aged, filtered, and pasteurized, it should be finally packed in small containers. This is the best way to preserve it for home use and is the most acceptable form in which it can be offered for sale to the ordinary consumer. The common method of keeping vinegar in the barrels in which it was stored after acetification and drawing out from time to time the quantities needed for immediate use is not a good practice; it permits the entrance of air and interferes with the sedimentation of the vinegar.

For the final packing of vinegar, receptacles which are most suitable in form and size and which will not be attacked by the vinegar should be selected. Metal containers, of course, are not to be considered. The most suitable containers are glass bottles, jars, or jugs. (Fig. 8.) They should be filled full and tightly sealed.

Vinegar made in small quantities by household methods may be stored in bottles. These are also largely used under commercial conditions to supply customers who want to buy only in small quantities. Ordinary glass-top fruit jars can be utilized in the home. Perhaps the most desirable containers for both home and commercial use are glass jugs, which may be obtained in almost every size up to 2 gallons capacity, the 1-gallon jug being a favorite.

As stoppers for all these containers, except the fruit jars, ordinary wood corks may be used, but they should be of the best material and free from cracks. Corks are greatly improved by being soaked in hot paraffin. Paraffined corks should not be used to seal containers holding hot vinegar, however, for the reason that the paraffin would probably liquefy and soil the surface of the pack. When the vinegar is packed for sale, the corks should be well driven in and heated paraffin should be poured over the top. Glass-stoppered bottles are desirable for vinegar made in small quantities in the household, but they are often difficult to obtain and quite expensive. When fruit jars are used, only those which have glass covers should be selected. Metal covers should never be used for sealing vinegar. Even those which are cork-lined are undesirable.

After vinegar has been packed, the containers should be properly labeled. When it is made for sale, printed labels giving the following information are desirable: (1) Name and address of manufacturer; (2) kind and quantity of vinegar which the container holds; (3) strength, expressed as nearly as possible in grains (p. 27) or in percentage of acetic acid, or preferably in both.

CAUSES OF FAILURE.

The chief causes of failure in making vinegar are: (1) The use of material having too low a sugar content; (2) failure to recognize the fact that the making of vinegar involves two distinct fermentations (alcoholic and acetic) and that the first must be completed before the second begins; and (3) failure to stop acetification at the proper time. All of these causes have been discussed elsewhere in this bulletin and the remedy indicated.

Various malfermentations due to the presence of undesirable or destructive microorganisms also cause failure. All material used for making vinegar is contaminated to some degree with undesirable organisms which may have a harmful effect on the fermenting juices and may even grow at the expense of the desirable organisms. The only sure means of preventing such a result is to sterilize the raw material and use pure cultures. This, however, is usually neither possible nor desirable.

Malfermentations may be caused by false yeasts, molds, or undesirable bacteria. The mycodermæ, yeastlike organisms which nearly always accompany fruits and fruit juices, often develop upon exposure to the air, forming a scum on the surface of the juice. These organisms, which are known as *Mycoderma vini*, often called wine flowers, like the true yeasts, multiply by budding, but, unlike the true yeasts, grow only in the presence of oxygen, for which reason they are called aerobic, and have no fermenting value. They live on the medium on which they grow, being destructive to both fixed acids and alcohol. The presence of mycodermæ is objectionable in all of the fermentation industries and the scum formed by them should be removed whenever possible. This scum, which at first is thin, whitish, and smooth, grows rapidly, soon becoming thick, rough, and heavily wrinkled. It should not be confused with the acetic film which at first usually occurs as greasy looking spots on the surface and gradually spreads, becoming a grayish veillike covering over the entire surface. As a rule the acetic film later becomes a smooth, leathery membrane, which eventually sinks by its own weight, only to be succeeded by another similar formation. This membrane is made up of acetic bacteria and a gelatinous material given off by them.

Mold spores are often present in fruit juices and under favorable conditions, either alone or in combination with false yeasts and aerobic bacteria, may grow on the surface of fermenting juices. As molds have an unfavorable action on the flavors of these juices, their growth should always be prevented if possible.

The bacteria which may complicate a fermentation are usually the kind that can grow in the absence of oxygen—the so-called anaerobic type. The lactic group, the one most commonly found, is nearly always present to some extent in fruit and vegetable juices. If these bacteria occurred in large numbers they would undoubtedly cause cloudiness, increased acidity, and undesirable changes and flavors. Other forms of bacteria, such as the butyric or even putrefactive types, may develop in juices, especially in those of low acidity. Unless speedily checked, these organisms may soon produce changes which make the juices worthless. The development of acetic bacteria before the acetification stage is, of course, very undesirable.

All these organisms usually appear before or during the alcoholic stage. As a rule they can be prevented by securing at the start an active alcoholic fermentation. This is accomplished by adding at once a culture of active yeasts and by subjecting the fermenting juice to such favorable conditions as will render their growth rapid and certain. In this way they quickly gain precedence over all other organisms and the sugar in the juice is utilized before other organisms have an opportunity to attack it. The large quantity of carbon dioxide formed by an active yeast fermentation doubtless has a tendency to check the growth of all other organisms. Above all, it is important to secure complete utilization of the sugar before the acetic bacteria, which are always present to some extent, have an opportunity to form much acetic acid. The presence of even 0.5 per cent of acetic acid interferes seriously with the growth of yeasts and 1 per cent is almost prohibitive.

The failure of yeasts to grow in a juice which is ordinarily a favorable medium is probably due to a high acid content, or, in some instances, to the presence of an antiseptic agent added to prevent fermentation. It is useless to add more yeast to a juice of this kind. The only thing that can be done is to dilute it with fresh juice to a point where yeasts will grow and then add another culture.

Sometimes failure occurs during the acetic fermentation. Acetification may be slow in starting or may stop entirely, owing to the fact that the acetic bacteria are present only in small numbers or that those present are of a weak strain or of an objectionable type, like the *Bacterium xylinum.* In most cases failure is due to the fact that the medium is unfavorable to the growth of the acetic bacteria or that the temperature and air conditions are not favorable. As a rule acetic bacteria will grow in a medium which is only weakly acid or even slightly alkaline, but a more prompt and vigorous growth can usually be obtained in a decidedly acid medium. For this reason the addition of vinegar is always advisable, especially in the case of juices or solutions which are normally low in acid. The addition of vinegar also is a protection against the growth of undesirable organisms until enough acid is formed by oxidation of the alcohol present.

The solution to be fermented must contain the proper nourishment for both yeasts and acetic bacteria. The presence of sugar for the yeasts or of alcohol for the bacteria alone is not sufficient to insure their growth. Nitrogenous matter in some form must be present to make these organisms function properly. Fruit juices usually contain enough nourishment for the growth of yeasts and acetic bacteria, but not all the sugar solutions used for making vinegar do (pp. 4, 5).

Temperature is an important factor in making vinegar. If too high or too low this may be a cause of failure. Most yeasts do their work best at from 75° to 80° F., and most strains of acetic bacteria at from 80° to 86° F. As evaporation is likely to occur at these temperatures, somewhat lower ones are often preferred. If very much lower than those stated, the fermentations are certain to be slow. In general, it may be said that a very hot room or a very cold cellar is a poor place in which to make vinegar.

DARKENING OF VINEGAR.

Vinegar usually becomes darker with age. This slow darkening may be due to the presence of oxydase (an organic substance which promotes oxidation), just as fruits, vegetables, and fruit juices are darkened when exposed to the air. Moderate darkening which comes on gradually in vinegar usually need cause no great concern.

In many cases darkening doubtless is due to the presence of small quantities of iron and tannin. The presence in large quantities of iron or tannin or both may cause the vinegar at once to become very dark and in extreme cases even densely black. Tannin, a normal constituent of nearly all fruit juices, is present, in small quantities at least, in vinegar made from these juices. Tannic substances may also be extracted from new barrels in which vinegar is stored, especially when they have not been properly cleaned. Iron salts are not a normal constituent of vinegar, but they may be present as a result of the action of acetic acid on iron during the process of manufacture. They may also gain entrance through soil which clings to the fruit from which the vinegar is made. In nearly every case excessive darkening of vinegar is the result of the presence of iron salts. The inky blackness commonly caused by the combination in solution of iron salts and tannin occurs when iron salts are present in a fruit vinegar. The degree of blackening depends entirely upon the quantity of iron salts present. It is important, therefore, to prevent the entrance of iron salts into vinegar in every way possible. Darkening from this cause can usually be removed by "fining" with gelatin (p. 17).

While animal charcoal and vegetable carbons are usually effective in removing color from solutions (p. 16), their use as decolorizing agents for vinegar is open to several serious objections.

Free exposure to air undoubtedly favors the darkening of vinegar, regardless of what special cause is operating to produce this result. This constitutes another reason for protecting vinegar from exposure to air as far as possible.

ANIMAL PARASITES.

VINEGAR EELS.

Vinegar may become infested with small worms (*Anguillula aceti* (Muel.) Muel.), commonly called vinegar eels. Although very small, they can be seen with the unaided eye by holding the vinegar in a small glass before a strong light. They are harmless when taken internally, but very objectionable from an æsthetic standpoint. As these eels are apparently found only in vinegar or in connection with fruits or other substances which are undergoing acetic fermentation, they undoubtedly spread from such sources. They usually occur around the edges of acetic liquids and in the surface of the film. When sufficiently numerous they may destroy the film, causing it to sink, thus interfering with acetification. When very numerous they may give rise to a putrid decomposition which makes the vinegar unfit for use.

Vinegar eels are readily killed by heat, a temperature of 130° F. being sufficient for their destruction. Heat, therefore, in some form is the best means of getting rid of them. They are easily removed from finished vinegar by filtration, followed by pasteurization. Barrels, tanks, and generators which contain them should be sterilized by steam.

VINEGAR MITES.

Unless great care and cleanliness are observed in connection with vinegar production, mites (*Tyroglyphus longior* L. and *Tyroglyphus siro* Gerv.) may appear in large numbers and prove very troublesome. They are undoubtedly identical with the mites often present in cheese and other food products.[12] Under favorable conditions of warmth and moisture, these mites breed with great rapidity, and unless proper precautions are taken they may enter vinegar casks and generators, spoiling the contents.

Mites are readily destroyed by the use of hot water or steam. If a room becomes badly infested, it should be cleaned, fumigated with sulphur, and thoroughly washed with kerosene emulsion. The entrance of mites into vinegar casks may be prevented by painting a ring of turpentine or kerosene oil around the openings.

VINEGAR FLIES.

Several species of light-brown flies (*Drosophila* spp.) breed in the juices of decaying fruits and also around the openings of vinegar containers or wherever they find vinegar exposed to the air. These are known as fruit or vinegar flies. If very numerous, the larvæ of these flies may get into the vinegar and cause its deterioration. They may also be responsible for the introduction of the *Bacterium xylinum*, an undesirable member of the acetic group.[13]

The presence of these flies may be prevented to a great extent by cleanliness and by avoiding the spilling of vinegar and the leakage from casks. The importance of keeping all openings in casks well screened has already been mentioned.

VINEGAR BEES.

Substances with such names as "vinegar bees" and "California bees" are sometimes advertised for use in making vinegar. As extravagant claims have been made for some of these preparations, a word of caution about them should be given. These so-called "vinegar bees" are not insects, as the name implies, but a combination of yeasts and bacteria in a suitable medium. As the "bees" are usually the result of chance inoculation, the yeasts present are not as a rule actively fermenting strains and the bacteria are ordinarily a mixed culture which may contain harmful as well as desirable types. Molds also are often present. Even if the "bees" should contain none but desirable microorganisms—that is, yeasts and acetic bacteria—their use would still be fundamentally wrong, for the reason that they would bring about the simultaneous action of alcoholic and acetic ferments which is to be avoided (p. 19).

TESTS.

In making vinegar certain tests are necessary for accurate results. Unfortunately there are no simple tests which are dependable. It is not safe to assume that the alcoholic fermentation is complete when bubbling or frothing ceases; nor can tasting during the acetic fermentation be depended upon to show when the acetic fermentation has gone far enough. Reliable tests are needed to determine (1) the sugar content of the material from which the vinegar is to be made, (2) the quantity of alcohol formed during the first fermentation, and (3) the quantity of acetic acid formed during the second fermentation. They call for additional apparatus not ordinarily found in the home or on the farm.

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[12] L. O. Howard and C. L. Marlatt. The Principal Household Insects of the United States. U. S. Dept. Agr., Div. Ent. Bul. 4 (1896), pp. 100–111.

[13] G. Bertrand. Préparation biochimique du sorbose. *In* Compt. rend. (1886), vol. 122, pp. 900–905.

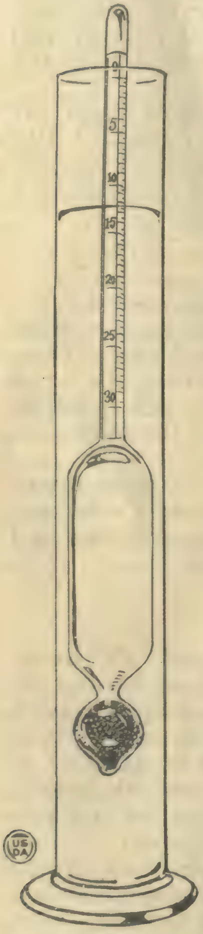

FIG. 9.--Sugar hydrometer.

SUGAR.

A quantitative chemical analysis is necessary to determine accurately the sugar content of the juice or solution used in making vinegar. Very few persons can make a test of this kind; moreover, great accuracy is not usually required. Ordinarily this information can be obtained with a sufficient degree of accuracy by the use of a sugar hydrometer[14] which shows the sugar content of any pure sugar solution. (Fig. 9.)

This test should, of course, be made before fermentation begins. The hydrometer should be cleaned thoroughly and dried each time before being used and it should be handled with clean, dry hands or with a clean cloth. The juice to be tested should be quite fluid—that is, it should not contain enough solid matter to make it thick or slimy; otherwise, the resting point of the hydrometer will be uncertain. A small quantity of the juice is poured into a glass cylinder, and the hydrometer is dropped in carefully. (Fig. 9.) The instrument must float freely and touch neither the bottom nor walls of the cylinder.

To determine the correct reading, put the eye on a level with the surface of the liquid and note where the true surface intersects the scale. The film of liquid which is drawn by capillarity up around the neck must be disregarded.

The specific gravity of juices varies with the temperature. Therefore the juice must be brought to the standard temperature for which the hydrometer is adjusted (usually 60° F.) or a temperature correction should be made. This correction is very nearly 0.1 per cent for every 3° F. above or below the standard. If the temperature is higher, this correction must be added; if it is lower, it must be subtracted.

The approximate percentage of sugar in fruit juices which corresponds to the hydrometer reading is shown in Table 1.

As fruit juices contain substances other than sugar which increase the reading, the true sugar content of these juices is always from 0.5 to 2.5 per cent less than that indicated by the hydrometer.

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[14] Either a Brix or a Balling hydrometer may be used. A Brix hydrometer, graduated from 0 to 30, is well adapted to this purpose.

ALCOHOL.

As a result of the utilization of sugar during fermentation, the hydrometer reading gradually approaches the zero point. This instrument, therefore, may be used to determine the progress of a fermentation and its probable completion. When the quantity of material to be fermented is small enough to admit of its being weighed accurately, this information may also be obtained, with perhaps a greater degree of accuracy, by weighing the fermenting mass from day to day, thereby determining the loss of weight due to the escaping carbon dioxide. When loss of weight has practically ceased, the fermentation may be regarded as complete.

When the fermentation of a juice or sugar solution is complete it no longer contains sugar. This has been converted into alcohol and carbon dioxide gas, the alcohol remaining in the liquid and the gas passing into the atmosphere. The fermented juice should then contain a quantity of alcohol which approaches closely to that indicated by the original hydrometer reading. (Table 1.) The exact quantity of alcohol resulting from a fermentation can be determined only by distillation.[15]

ACETIC ACID.

The acid strength of a vinegar can be determined accurately only by titration against an alkaline solution of known strength. For this purpose normal sodium hydroxide is ordinarily used. The simplest way to do this is to measure carefully with a pipette 10 cubic centimeters of the vinegar to be tested into a porcelain evaporating dish, adding a few drops of a 0.5 per cent solution of phenolphthalein in 50 per cent alcohol as an indicator. The normal sodium hydroxide is then run in very slowly, preferably using a 50 cubic centimeter burette graduated in tenths of a cubic centimeter. As the sodium hydroxide is being added the juice should be stirred constantly. When the entire well-stirred mixture shows a permanent faint pink tint the neutral point has been reached.

The exact quantity of sodium hydroxide required to neutralize the mixture in the dish, multiplied by 0.6, gives the number of grams of acid per 100 cubic centimeters, calculated as acetic, present in the vinegar. For example, if the burette reading shows that 7.5 cubic centimeters of sodium hydroxide is required to neutralize the mixture, the grams of acetic acid in 100 cubic centimeters of the vinegar would be 4.5, which, for convenience, is usually stated as 4.5 per cent.

As any laboratory method of determining the acid strength of vinegar is somewhat complicated and calls for apparatus and chemicals which are not always available, it may be better to use some form of vinegar tester. In that shown in Figure 10 the quantity of acetic acid is determined by the volume of gas given off when bicarbonate of soda (baking soda) is treated with a measured quantity of the vinegar to be tested.

A quantity of vinegar is measured in the small tube (A) and poured into the bottle (B). A small quantity of sodium bicarbonate

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[15] Alcohol determinations are not essential and are seldom made except in the commercial production of vinegar. Those who desire to make such a test should consult the methods of the Association of Official Agricultural Chemists or books relating to analytical chemistry.

(about 1 gram), taken with the scoop (C), is introduced into the bottle (B) in such a way that it does not come in contact with the vinegar until after the bottle has been tightly closed with the cork (D). Vigorous shaking will cause the soda and vinegar to unite, with the resulting formation of carbon dioxide gas. This gas passes through the rubber tube (E) and causes the water within the reservoir (F) to rise in the graduated cylinder (G). The stronger the vinegar the more gas will be given off and the higher the water will rise in the cylinder, which is graduated in such a way that the acid strength of the vinegar may be read off directly, either in grains (p. 27) or in percentage of acid.

The following precautions should be observed in making this test: (1) The bicarbonate of soda used must be pure, a reliable brand of baking soda being satisfactory. (2) The soda must be introduced in such a way that none of it comes in contact with the vinegar until after the bottle is tightly corked. (3) There must be no leaks in the apparatus. The presence of leaks can be determined by allowing the column of water to remain for a few minutes in the cylinder after making a determination. If the column does not fall during this time there are no important leaks. (4) Neither very cold nor very hot water should be used; the instrument is made for use with water at ordinary temperatures.

The apparatus and chemicals required for making these tests may usually be procured through local druggists, or they may be obtained from dealers in laboratory apparatus and supplies.

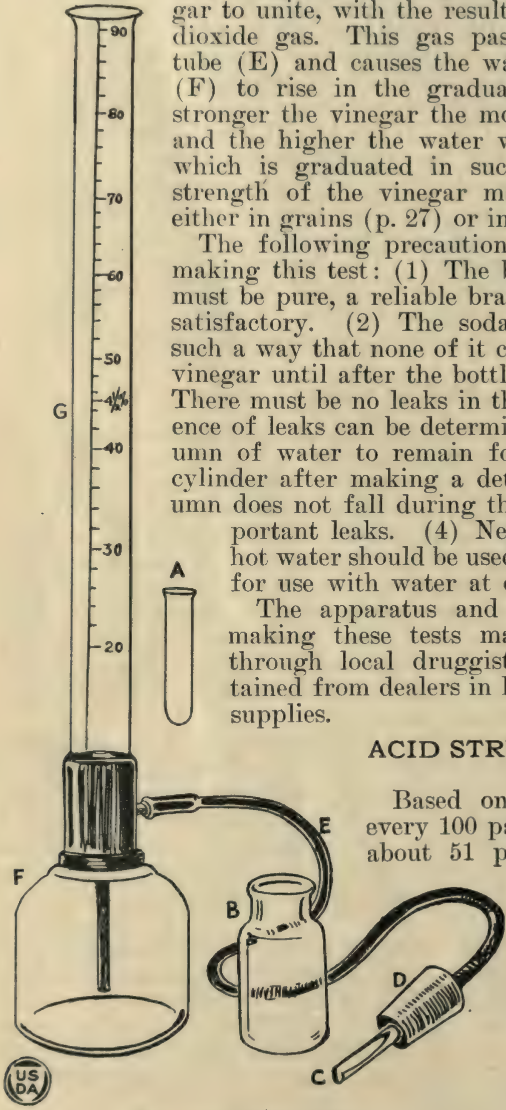

FIG. 10.—Vinegar tester.

ACID STRENGTH OF VINEGAR.

Based on the molecular weight, every 100 parts of sugar should give about 51 parts of alcohol and 49 parts of carbon dioxide gas. As small quantities of sugar are consumed as food for the yeasts or may be lost in the production of other substances, however, no more than 45 to 47 parts of alcohol are obtained.

Theoretically, again, 100 parts of alcohol should yield about 130 parts of acetic acid. Because of evaporation and other causes, however, less than 120 parts are obtained. Hence, starting with 100 parts of sugar, it is possible, under very favorable conditions, to get from 50 to 55 parts of acetic acid. In order to insure a vinegar with

4.5 per cent of acetic acid, a juice which gives a hydrometer reading of about 12 should be used. (Table 1.)

Table 1.—*Hydrometer readings (Brix or Balling) of fruit juices, approximate percentages of sugar before fermentation, and percentages of alcohol that can be produced.*

Hydrometer reading (Brix or Balling).	Sugar.	Alcohol.	Hydrometer reading (Brix or Balling).	Sugar.	Alcohol.	Hydrometer reading (Brix or Balling).	Sugar.	Alcohol.
°	*Per cent.*	*Per cent.*	°	*Per cent.*	*Per cent.*	°	*Per cent.*	*Per cent.*
10.0	7.5	3.7	12.6	10.1	5.0	15.0	12.5	6.2
10.3	7.8	3.9	12.9	10.4	5.2	15.2	12.7	6.3
10.5	8.0	4.0	13.1	10.7	5.3	15.4	12.9	6.4
11.0	8.5	4.2	13.3	10.8	5.4	15.7	13.2	6.6
11.2	8.7	4.3	13.6	11.1	5.5	16.1	13.6	6.8
11.5	9.0	4.5	13.8	11.3	5.6	16.3	13.8	6.9
11.7	9.2	4.6	14.0	11.5	5.7	16.6	14.1	7.0
11.9	9.4	4.7	14.3	11.8	5.9	16.8	14.3	7.1
12.2	9.7	4.8	14.5	12.0	6.0	17.0	14.5	7.2
12.4	9.9	4.9	14.7	12.2	6.1			

The percentages of sugar given in Table 1 are 2.5 less than those indicated by the hydrometer readings. While this difference is not true of all fruit juices, it is true of many. Analyses of a large number of apple juices made by the Bureau of Chemistry have shown that the nonsugar solids usually constitute about 2.5 per cent of the juice. This difference affords a safe basis for the estimation of the probable results of a fermentation. The percentages of alcohol by weight given are half the sugar content. Common experience has shown that this is the usual result of a normal fermentation. As the percentage of acid formed by acetification as a rule exceeds by little, if any, the percentage of alcohol present, it is possible by a very simple calculation to estimate from the hydrometer reading of a fruit juice the strength of the vinegar it will produce. For example, if the hydrometer reading of a juice is 12.5, subtract 2.5 to get the percentage of sugar. This result, divided by 2, gives 5 as the probable percentage of acetic acid which should be obtained in the finished vinegar. Owing to various causes which have been explained in this bulletin, such a result is by no means always obtained. The only method for determining the actual strength of the vinegar obtained is the use of a test for acidity.

The acid strength of vinegar is determined by finding the acidity of the vinegar in terms of grams of acetic acid per 100 cubic centimeters. Since the specific gravity of vinegar is but slightly greater than that of water, 100 cubic centimeters of vinegar weigh little more than 100 grams. Grams per 100 cubic centimeters is therefore nearly but not quite the same thing as percentage by weight. The difference is so slight that it is usually disregarded by manufacturers and dealers and the strength of the vinegar is stated as 4, 5, or 6 per cent, etc.

The grain system of expressing the strength of a vinegar is also often used. As now used in this country, the grain, which is the unit of this system, is equivalent to 0.1 gram of acid per 100 cubic centimeters of vinegar. A 4 per cent vinegar therefore is a 40-grain vinegar; a 6 per cent vinegar is a 60-grain vinegar; etc.

FEDERAL REGULATIONS GOVERNING THE MANUFACTURE AND SALE OF VINEGAR.

Vinegar may be made in the home and on the farm without a permit if it is to be consumed only in the home or on the farm where it is made. If it is to be offered for sale the maker must obtain a permit from the collector of internal revenue of his district. As the regulations governing the making of vinegar for sale are subject to change, anyone planning to make vinegar on a commercial scale should first obtain the most recent information about the laws from the Federal prohibition director of the State.

All vinegar which is shipped from one State to another or is offered for sale in any possession or Territory of the United States or the District of Columbia should meet the requirements of the Federal food and drugs act. This information may be obtained from the Bureau of Chemistry, United States Department of Agriculture, Washington, D. C.

As practically all States have laws governing the sale of vinegar, anyone interested in its commercial production should obtain the regulations from the State food commissioner.

In general, it may be said that the law requires that vinegar offered for sale in the United States should contain at least 4 per cent of acetic acid.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

May 22, 1924.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1425

The TOBACCO FLEA-BEETLE *in the* DARK FIRE-CURED TOBACCO DISTRICT

OF KENTUCKY & TENNESSEE

1862 1889

THE TOBACCO FLEA-BEETLE is second only in importance to the tobacco hornworms in the dark fire-cured tobacco district of Kentucky and Tennessee. On account of its small size and the insignificance of individual injuries its presence and ravages often pass unnoticed until considerable damage has resulted. Plant beds imperfectly protected by cheesecloth (commonly called "canvas") are sometimes entirely destroyed. In the field much of the transplanted crop may be either killed or badly stunted. Late-set crops suffer more severely than early-set crops, and the cumulative injury frequently reduces the value of the crop by many times the cost of applying remedial measures.

In this bulletin methods of control are recommended which will show a profit under the conditions for which they are advised:

Control of the tobacco flea-beetle in the southern cigar-wrapper district (northern Florida and southern Georgia) is discussed in Farmers' Bulletin 1352.

Washington, D. C. Issued July, 1924

THE TOBACCO FLEA-BEETLE[1] IN THE DARK FIRE-CURED TOBACCO DISTRICT OF KENTUCKY AND TENNESSEE.

By A. C. Morgan, *Entomologist*, and J. U. Gilmore, *Assistant Entomologist, Southern Field-Crop Insect Investigations, Bureau of Entomology.*

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ECONOMIC IMPORTANCE.

THE TOBACCO FLEA-BEETLE (fig. 1) is one of the most injurious insects affecting tobacco and is found in all tobacco districts of the United States. In the more northern districts it occasions very little injury and is strictly a secondary pest, but in the more southern districts it is of prime importance and in the dark fire-cured tobacco district of Kentucky and Tennessee is a pest second only to the tobacco hornworms. Since the adult insect, or beetle, is only from one-fifteenth to one-twelfth of an inch in length, it often escapes notice until present in very injurious numbers. It injures the plant by eating small holes partly or entirely through the leaves (fig. 2) and owing to the nature of the injury the damage is not always so apparent as that of other and larger insects. No other insect attacking the tobacco plant feeds upon it from the day it appears above the ground until the crop is partially cured. No accurate estimate can be placed upon the damage caused by this pest, although it amounts to many thousands of dollars annually.

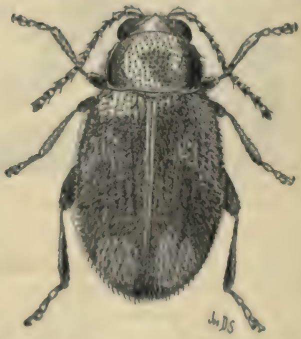

Fig. 1.—Adult tobacco flea-beetle. Twenty times natural size.

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[1] *Epitrix parvula* Fab.; order Coleoptera, family Chrysomelidae.

COMMON NAMES AND HABITS.

The tobacco flea-beetle derives its name from its habit of jumping like a flea when disturbed. In some portions of its range it is also called the "tobacco flea," the "tobacco flea bug," or simply "flea bug." Many people are of the opinion that this insect is a true bug and derives its nourishment from sucking the juices of the tobacco plant. This belief is erroneous. It is a true beetle and obtains its food by biting off and eating portions of the leaves.

When disturbed the tobacco flea-beetle usually hops to some other portion of the plant or to the ground, although occasionally it may take wing. Flights with the breeze of as much as one-half mile have been recorded.

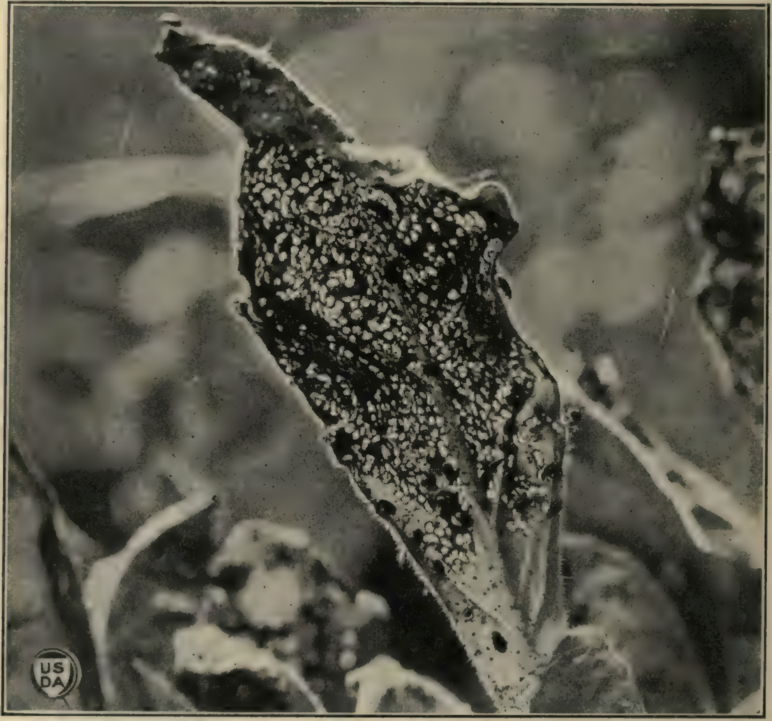

FIG. 2.—Tobacco leaf in plant bed showing flea-beetles and typical injury. Enlarged $1\frac{1}{2}$ times.

On the plant bed the beetles feed mainly on the upper surface of the leaves but in the field they feed mainly on the lower surface. Feeding continues after the tobacco has been hung in the barn and until the heat from the curing fires drives the beetles out or kills them. The beetles lay their eggs singly or in small clusters in crevices in the soil at or near the surface. The larvæ, or young, which hatch from the eggs, feed upon the rootlets of the tobacco plants that have furnished food for the parent beetles. Upon becoming full grown the larvæ enter the pupa stage—the stage of transformation to the adult—in cells in the ground near their place of feeding.

SEASONAL HISTORY.

This insect passes the winter in the adult or beetle stage under leaves and trash, in fence rows, around the edges of tobacco fields, or in adjoining woods. Emergence from hibernation begins late in March and may continue for more than a month. Egg laying begins early in May and may continue for as long as two months for the overwintered beetles. The first eggs deposited produce beetles in about two months; the beetles of the first generation therefore appear about July 1. The beetles of the second generation appear in August, and those of a third may appear late in September, although the second and third generations so overlap as to be practically indistinguishable.

FOOD PLANTS.

The beetle prefers tobacco as a food plant but it may feed upon many other plants. The common ground cherry[2] is the beetle's second choice of a food plant, and Jimson-weed,[3] a nightshade,[4] eggplant, and tomato are the other preferences in about the order named. Other plants of the potato family are fed upon to a lesser degree.

Under adverse conditions this beetle has been known to exist upon the leaves of various trees. The common chickweed[5] is an important food plant of this insect, and wild mustard,[6] pokeweed,[7] and cowpeas are fed upon freely at certain seasons of the year.

PLANT-BED INJURY.

Injury in the plant beds usually begins around the margins as soon as the young plants appear and often spreads over the entire bed, increasing in severity as the emergence nears its maximum. The month of April is the period of greatest plant-bed injury. During unseasonably cool weather feeding may continue uninterruptedly throughout the month. On the other hand, a few exceptionally warm days will so increase the temperature beneath the cheesecloth that the beetles will be driven out and injury may cease, temporarily. Should the warm weather continue, no further beetle damage will occur. A return of cool weather, however, is very likely to bring about a return of the beetles and a resumption of feeding and injury.

Under conditions favorable for maximum beetle damage plant beds may be, and often are, entirely destroyed, thus necessitating reseeding. Reseeded beds always produce late plants and a late-set crop, which is more subject to insect injury than earlier set crops.

When the injury is lighter it is usually confined to the margins of the bed and to areas beneath holes in the cheesecloth. The injured plants are always stunted and are rarely large enough to use in the first settings.

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[2] *Physalis virginiana* Mill.

[3] *Datura stramonium* L.

[4] *Solanum nigrum* L.

[5] *Alsine media* L.

[6] *Sinapis arvensis* L.

[7] *Phytolacca americana* L.

FIELD INJURY.

The next injury occurs shortly after the tobacco has been set in the field. The beetles are particularly fond of a wilted leaf touching the ground, and while the crop is becoming established they may concentrate upon the newly-set plants in such numbers as to destroy them. Lesser injuries often continue after the plants start growing and cause them to be much stunted. The larvæ of the tobacco flea-beetle are reared mostly upon the tender rootlets of the tobacco plants and this damage, though considerable, is not so apparent as the injury to the visible portion of the plant by the adult beetles. Replants to take the place of those injured or killed by flea-beetles are usually slower in growth and fail to mature, or "ripen," with the remainder of the field, which is a further loss in addition to the cost of replanting.

It is, however, during the later stages of the plant's growth that the really severe flea-beetle injury occurs. This is particularly true when the tobacco is about half grown. Late crops also suffer more from beetle damage than do the earlier plantings. The beetles have then multiplied and searched out the younger and more succulent tobacco plants. Replants are especially liable to beetle injury at this time. Earlier in the season a plant attacked and injured or killed by flea-beetles can be replaced with some degree of success, but a plant half grown or larger represents a considerable monetary investment and can not be replaced by replanting. Damage done to a plant at this stage is therefore permanent. The feeding punctures of the beetle render the leaf of poor quality, reduce the weight, and considerably reduce the price when the tobacco is placed upon the market. It is here that severe monetary loss appears; how much, no one knows accurately, since most of the tobacco grown in the dark fire-cured belt always has a certain amount of flea-beetle injury. Ex-

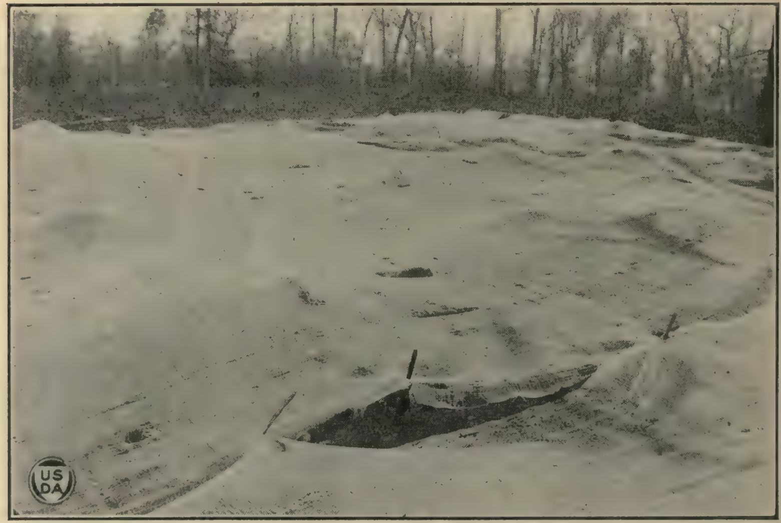

FIG. 3.—Tobacco plant bed improperly covered with cheesecloth.

ceptional infestations averaging more than 100 beetles per plant have been recorded. Such an infestation would soon render the plant of little value. Infestations of 50 to 75 beetles per plant are not uncommon, while many fields may be found with an average of 20 to 30 per plant. Any of these degrees of infestation will occasion considerable loss if remedial measures are not promptly employed. Hardly a field of topped tobacco can be found that does not have an average of 5 to 10 beetles per plant. Although feeding is confined chiefly to the lower and least valuable leaves, yet in the severer infestations considerable damage may result to the middle and upper, and higher-priced leaves and particularly to that small percentage of leaves which fall into the high-priced wrapper class.

LOCATION AND PROTECTION OF THE PLANT BED.

Plant beds located near a wooded area or other favorable hibernating quarters invariably show much more flea-beetle injury than beds located some distance from such sources of infestation. It is advisable, therefore, where practicable, to locate beds as far as possible from such sources of beetle supply.

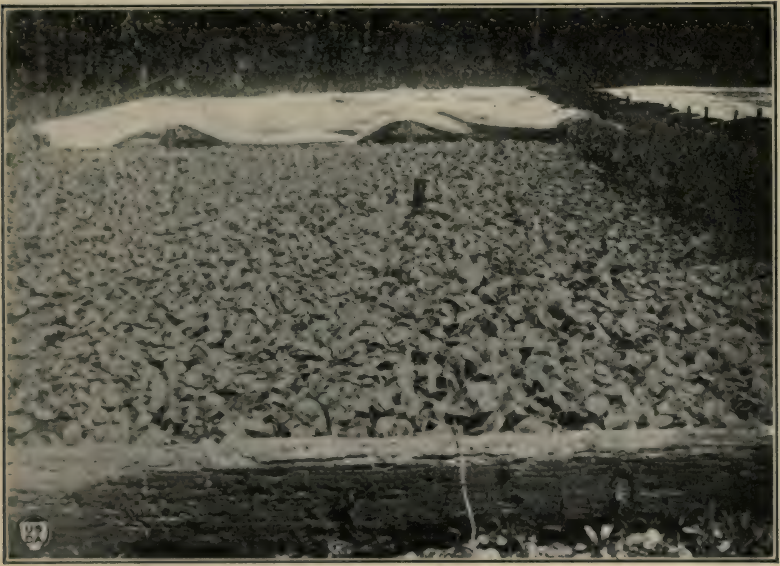

FIG. 4.—Typical stand of tobacco plants in a plant bed properly covered with cheesecloth.

The first operation in the preparation of a plant bed is the thorough burning or steaming of the soil in the space provided for the bed. This kills all flea-beetles hibernating in the leaves or trash in the treated area but must not be relied upon to prevent later flea-beetle injury. The next operation is the placing of boards or poles around the margins of the bed to support the cheesecloth with which all plant beds are covered immediately after sowing, and carefully banking soil around these boards or poles to prevent entrance of the beetles. The cheesecloth covering shown on the title page serves a dual purpose. It tends to maintain more even conditions of temperature and moisture and also to protect the bed from the entrance and consequent ravages of insects. Only cheesecloth of good quality should be used, the mesh being small enough to prevent beetles from passing through it. Cheesecloth having about 25 strands to the inch is the right grade. Old and worn cheesecloth, even when carefully stretched, will soon tear and become full of holes (fig. 3) through which flea-beetles may gain unrestricted access to the bed from surrounding hibernating quarters. After the bed has been sown, extreme care should be taken to tack the cheesecloth to the poles so that there will be no openings for the admittance of beetles.

Where the bed has been properly prepared, as shown on the title page, by banking the earth up around the margins and by covering it with sound, well-sewed cheesecloth, closely and securely fastened to the margin poles, little or no flea-beetle damage will occur. In addition, a bed well protected by cheesecloth has fewer weeds and a more uniform stand of plants. (See figs. 4 and 5.)

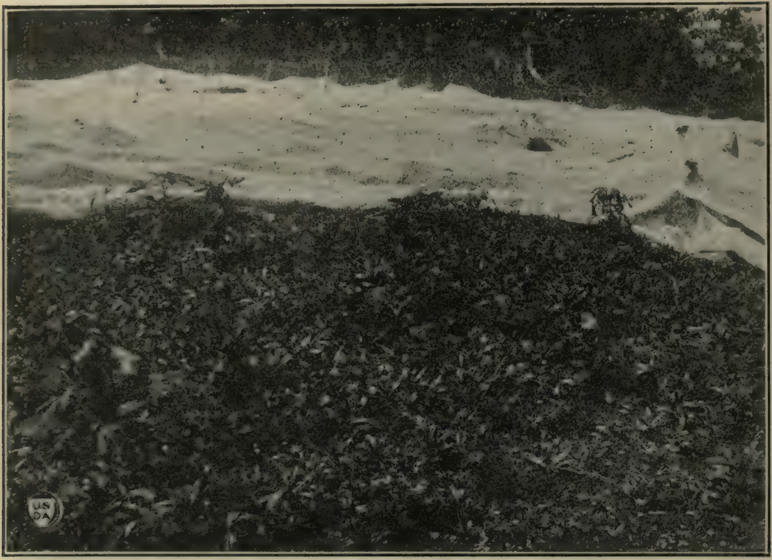

FIG. 5.—Typical stand of tobacco plants in a plant bed improperly covered with cheesecloth.

CONTROL OF THE FLEA-BEETLE IN THE PLANT BED.

Few farmers recognize that most plant-bed injuries and injuries to late and half-grown tobacco are caused by the same insect—the tobacco flea-beetle. The usual diagnosis made when a plant bed shows some flea-beetle injury is that the damage was done by the black flies seen under the canvas when the edge of it is raised. This is impossible, for these black flies are sucking insects and *do not feed upon the tobacco plant.*

As previously stated, if an infestation of the plant bed is noted, the injury is usually seen first about the outer edges of the bed. An excellent remedy is to apply a mixture of 1 part of Paris green with 5 parts of arsenate of lead at the rate of one-half pound per 100 square yards of plant bed. This poison will not burn or injure the plants in any manner and is effective in controlling the beetles. Usually one application will be sufficient, unless a rain falls a short time after the treatment, in which case the application must be repeated. The poison may be applied with a crank duster or bellows duster, or may be shaken through a cheesecloth bag. Care should be taken to prevent a spotty application since large deposits of this poison might burn where too heavily applied. Furthermore, excessive dosages are wasteful.

Very often with the crank duster good applications may be made without removing the cheesecloth, but the tobacco plants should be examined to be certain of this. Figures 6 and 7 show methods of applying poison to plant beds.

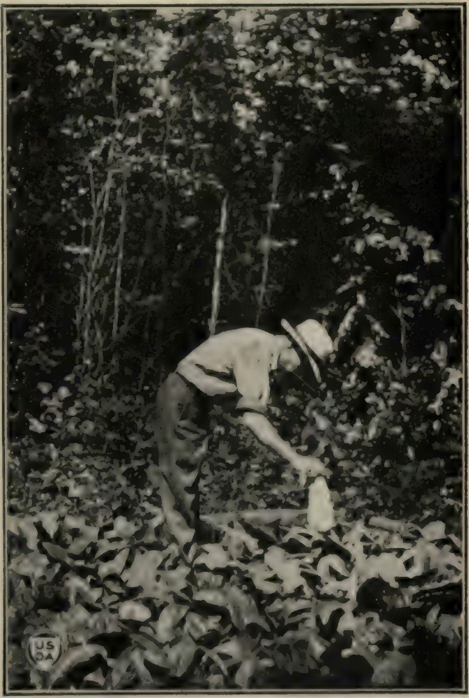

FIG. 6.—Dusting tobacco plant bed with cheesecloth bag.

Both Paris green and arsenate of lead will kill the flea-beetles that infest these materials, but it has been shown, as the result of numerous experiments, that arsenate of lead repels the beetles to a considerable extent. Paris green is fed upon much more readily than is arsenate of lead and has proved to be an excellent flea-beetle remedy. The combination protects plants better than either used singly. The arsenate of lead acts as a sticker, a repellent, and an insecticide, and is particularly advised for plant beds in which the cheesecloth must be removed to allow the most thorough application, and for field applications where the tobacco hornworms must also be controlled.

CONTROL ON NEWLY SET PLANTS.

A number of farm practices are in use in the dark fire-cured tobacco district which are of considerable value in controlling the flea-beetles on newly set tobacco. The more important methods are the use of (1) the "stick can," (2) the cheesecloth bag, and (3) the crank duster. These methods are somewhat wasteful of poison.

especially the one last mentioned. The "stick can" consists of a quart cup with nail holes in the bottom, fastened to a stick, and the poison mixture is sifted upon each plant as the operator walks between the rows. The usual formula for this method is 1 pound of Paris green mixed with 20 to 40 pounds of flour, about 5 pounds of the mixture being applied per acre. A type of bellows duster

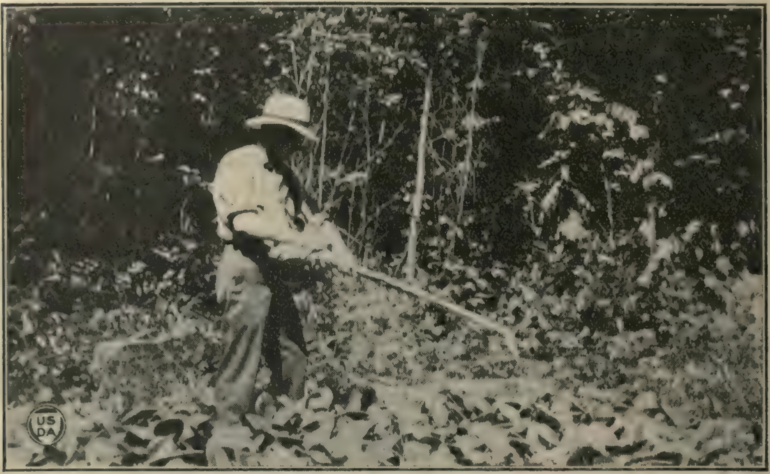

FIG. 7.—Dusting tobacco plant bed with crank duster.

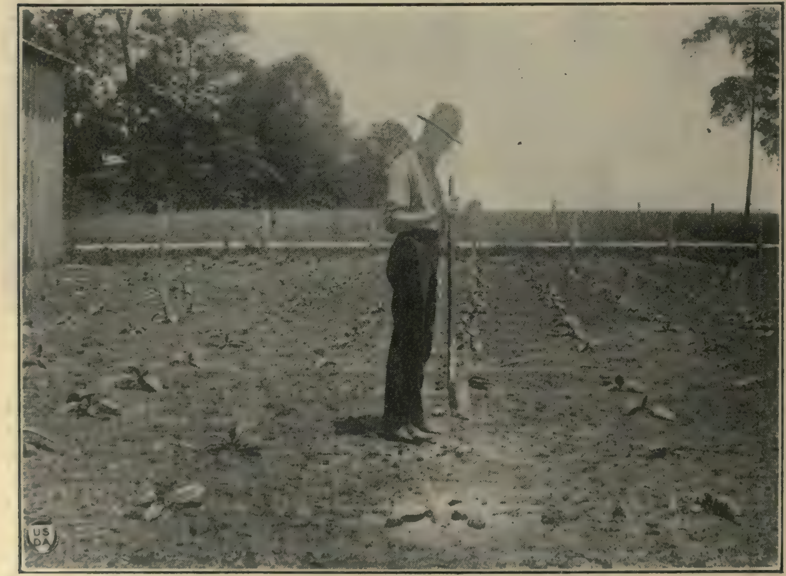

FIG. 8.—Dusting newly set tobacco plants with the stick can.

is on the market which is excellent for applying small quantities to individual plants and its use is the least wasteful of the four methods suggested. One puff is given to a plant and but little poison is lost in going from one plant to the next, which is not true with the crank duster which delivers poison continuously. It is necessary to add a diluent (flour) only when applying poison with the "stick can." For the other methods of application use the "one-in-six" mixture (1 pound of Paris green to 5 pounds of arsenate of lead) at the rate of 3 pounds per acre.

Two of the methods of applying poison to newly set plants mentioned above are shown in Figures 8 and 9.

An additional method of control for newly set plants is to dust the plant bed, prior to pulling the plants, with the one-in-six mixture of Paris green and arsenate of lead. Use 1 pound of the mixture to 100 square yards of bed. If it is more convenient to spray than to dust the bed, use 1½ to 2 pounds of the foregoing mixture in 50 gallons of water. Pull the plants at once or as soon as dry, and set. Enough of the poison should adhere to these plants to enable them to withstand or at least to minimize flea-beetle injury. Unfortunately for this plan of control, rains are usually frequent at setting time and much of this pre-pulling poison application may be washed off. Rains, however, would interfere with any of the three previously-mentioned methods.

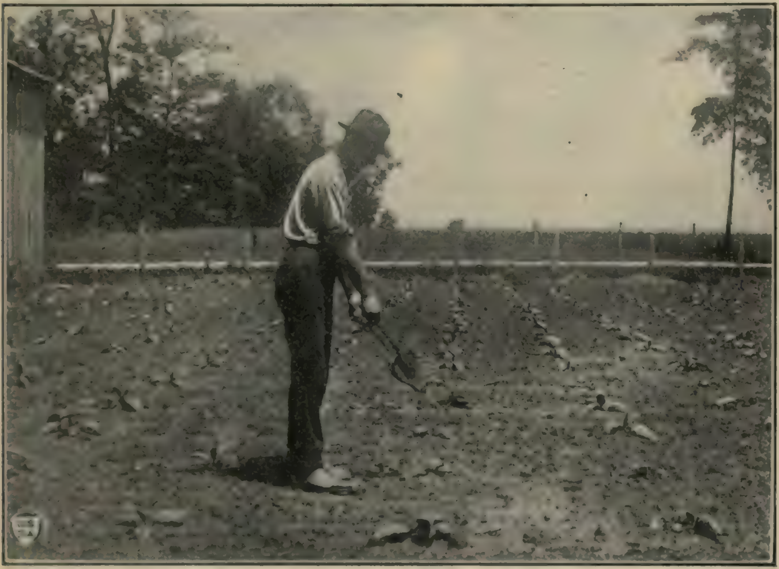

FIG. 9.—Dusting newly set tobacco plants with the bellows duster.

FIELD CONTROL.

Later in the season when the tobacco is topped, flea-beetles often become numerous and the tobacco may be seriously damaged. This is especially true of late tobacco. An average of 5 to 10 beetles per plant suggests that control measures may soon be necessary, for this small number may be quickly augmented to 25 to 50 per plant.

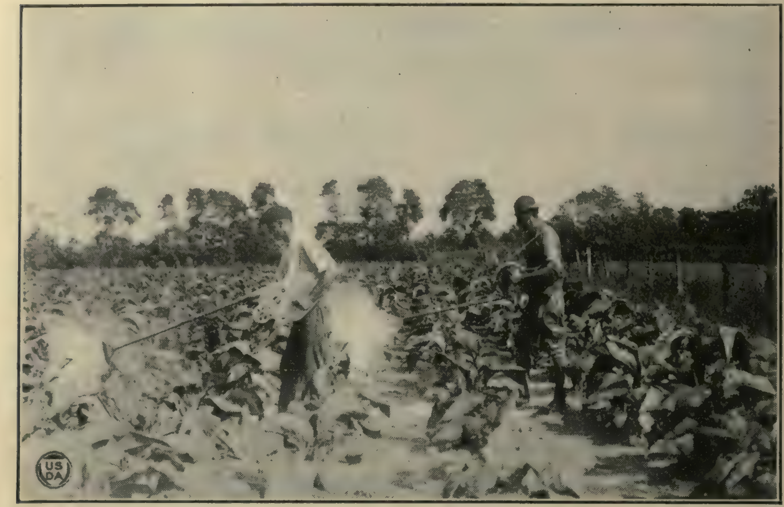

FIG. 10.—Dusting half-grown tobacco with the crank duster.

At present the most successful method of control is to poison the field tobacco infested with flea-beetles with an application consisting of 1 pound of Paris green to 5 pounds of arsenate of lead, using from 4 to 6 pounds of the mixture per acre. An even application is an absolute necessity if noticeable results are to be obtained. This amount of Paris green ($\frac{2}{3}$ pound to 1 pound per acre) should not

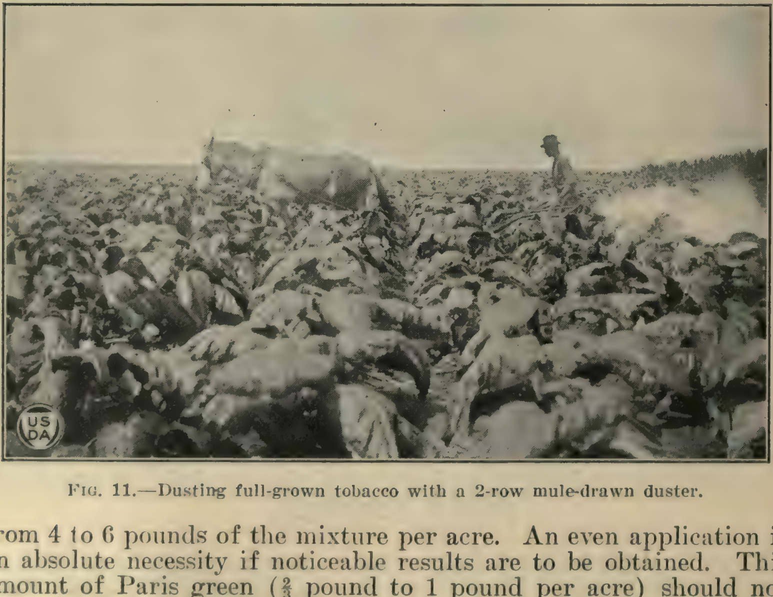

FIG. 11.—Dusting full-grown tobacco with a 2-row mule-drawn duster.

injure the tobacco in the least. The arsenate of lead when evenly applied should not " spot " the leaves and the mixture of Paris green and arsenate of lead offers a wonderful measure of flea-beetle control.

Another result of prime importance in the use of the foregoing mixture at the rate specified is that it is equally efficient as a hornworm insecticide.

Mention should be made of the types of apparatus available for the application of the flea-beetle insecticide to large tobacco. Crank dusters (fig. 10) are now on the market which can be operated efficiently by the tobacco grower of small acreage. For the grower having 25 acres or more there is the choice between the saddle-back duster and the 2-row mule-drawn duster (fig. 11). Any of the three types operate successfully in the dark fire-cured type of tobacco, the size of the crop being the determining factor.

SUMMARY OF CONTROL MEASURES FOR THE TOBACCO FLEA-BEETLE.

Locate the plant beds as far as practicable from the flea-beetle hibernating quarters. Sow the seed early, bank the earth about the boundary poles, and use sound cheesecloth properly applied.

Poison the bed if flea-beetles appear, using the " one-in-six " mixture (1 pound of Paris green with 5 pounds of arsenate of lead) at the rate of one-half pound per 100 square yards.

Before pulling the plants dust at the rate of 1 pound of the mixture to 100 square yards of plant bed. If a liquid spray is preferred use from 1½ to 2 pounds of the mixture in 50 gallons of water.

For newly set plants use about 3 pounds per acre of the one-in-six mixture in all methods of application, except the " stick can." With the " stick can " the formula should be 1 pound of Paris green in from 20 to 40 pounds of flour, about 5 pounds of this mixture being applied per acre.

For field control on tobacco half grown or larger, use from 4 to 6 pounds per acre of the one-in-six mixture. This will control the hornworms or tobacco worms as well.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

March 15, 1924.

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